NUCLEAR POWER ON THE RUN

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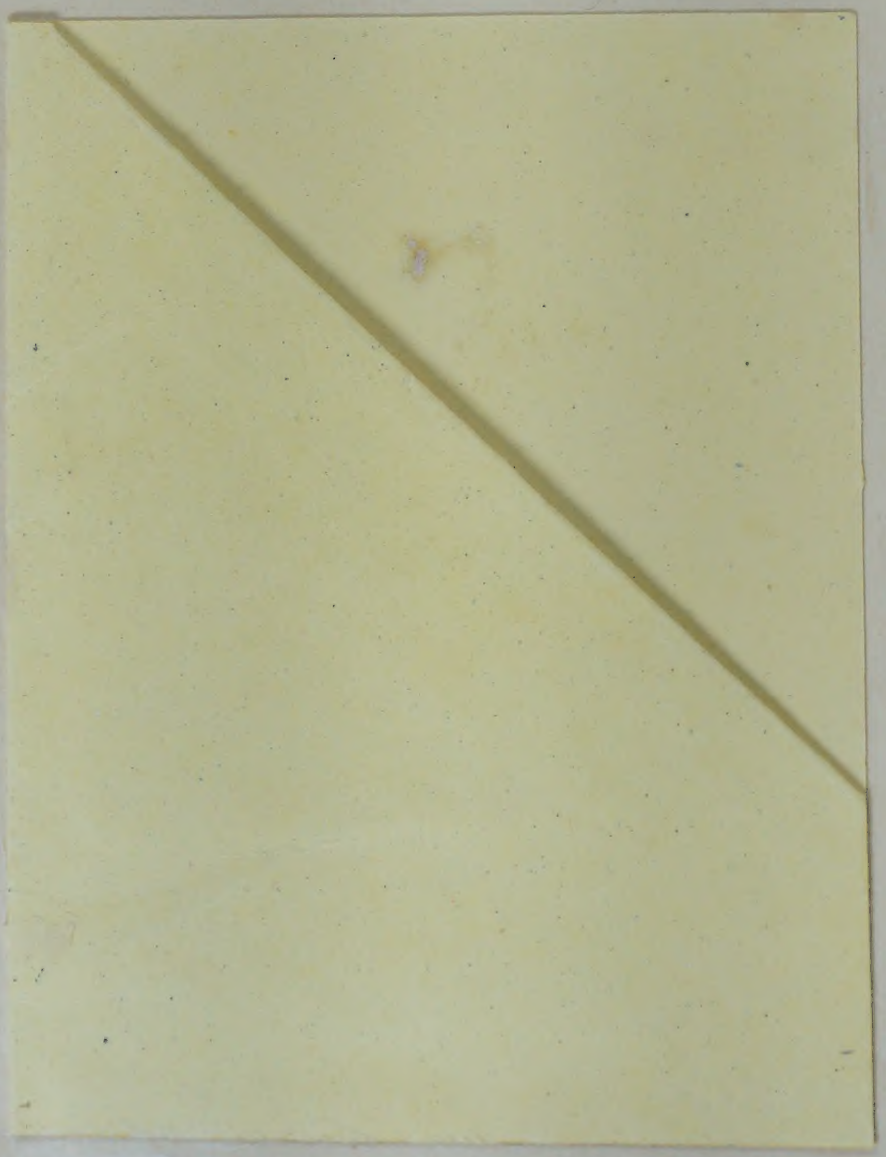

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I. Nuclear Power On The Run

The nuclear dream; of generating potentially limitless quantities of reliable, clean, safe and cheap power from atomic fission, lies all but shattered in India.

The country's spectacularly ambitious nuclear power programme is in a mess. In fact, barring only two exceptions — a growing awareness of the awesome magnitude of the problem of cooking fuel for the poor, and a recognition of the need to reorient energy planning priorities towards renewable sources — the acute crisis of the official nuclear programme constitutes the most momentous development of the last decade in India's energy sector.

The nuclear crisis is now too visible in all its numerous dimensions and its naked ugliness for anyone to pretend it is a transitory phenomenon or a peripheral aberration. Every single project undertaken by the government's department of Atomic Energy (DAE) has been a major environmental liability, an unmitigated technological disaster, an expensive commercial debacle, or a big planning and management fiasco, if not all four. Each of the targets set by the DAE has proved slippery. Each project schedule has been mauled out of shape, every deadline has proved impossible to meet, and all budgeted costs have in practice spilled over and overrun uncontrollably.

And, most important, the DAE has violated every single rule in the safety planner's and health physicist's book in exposing people to major health hazards and the environment to serious damage and risks, both actual and potential.

On every criterion set by the DAE itself, its performance has been a failure. All its objectives, whether "meeting the long term power needs of the country", or achieving "self-reliance", in nuclear techniques, or using them "in agriculture, industry, medicine and other areas", have persistently proved elusive.

Nothing reveals this as clearly as the desperation with which the DAE is now trying to imports whole nuclear reactors, thus reneging on the goal of "self-reliance" -- only because it is extremely unlikely to be able to achieve the target of establishing 10,000 MW of atomic power generating capacity by the year 2000 on its own.

Nuclear power, which claims more than half the Science and technology budget of the country and currently guzzles more than Rs.330 crores a year, contributes just over three per cent to India's electricity generation -- a level that is pitiably small not merely in itself but also in relation to the per cent share the DAE claims of the national investment plan for power generation. Nuclear power is an economic disaster.

What is worse, the Indian nuclear programme has, as will be argued later, proved a heavy liability, environmentally, socially and even politically. Its human costs; in terms of excessive radiation exposure of hundreds of people, one high, although essentially immeasurable.

Evidently, something has seriously gone wrong right at the core of the Indian nuclear power programme; the nuclear dream is turning into a nightmare.

The DAE, the Atomic Energy Commission (AEC - the policy-

making body of the government of India for nuclear energy) and its suporters of course deny this with a vehemence that is both characteristic and increasingly shrill. For them, the problems the nuclear programme has run into are both minor and temporary; they will be, as they are bound to be, overcome. But there can be little doubt that the proponents of nuclear power are now on the defensive. As they obsessively pursue the nuclear dream, and battle to preserve it, it becomes increasingly clear that nuclear power is itself on the run.

But how does one explain the curdling of the atomic plan? Was it necessary or inevitable, thanks to the nature of the technology itself? Or is it continget, deriving from the mishandling of the technology by India's scientocrats?

Is it possible to question the vision the many assumptions about technology, development and society, underlying the nuclear power really necessary? Is there an alternative to it?

Is it really safe? What environmental problems does it actually pose? Can anything be done to solve these and to improve its safety?

Is nuclear energy cheaper than electricity produced by burning coal or oil? If it is not today, is it likely to or certain to become cheaper in the near future? But can be done to improve its economic viability in India? Is the fast breeder reactor a genuine solution?

Is it possible, as the advocates of nuclear power say, that nuclear critics are irrational, alarmist, unrealistic, defeatest and irresponsible at the same time? Is there any substance in the

environmentalist critique of nuclear energy?

Can the Indian atomic power programme be salvaged? What would be the cost of rejecting the nuclear option altogether? Is it at all likely that, after an initial period of "teething troubles", nuclear power will prove viable, necessary and desirable as a safe, cheap and reliable form of energy?

This chapter seek to pose and answer some of these questions. Its point of departure is the fact that these questions can be, and indeed are being raised in the first place in the larger society. This in itself is a measure of the strength of the critical element in the public attitude towards and growing awareness of nuclear energy and the problems it is fraught with. For first ten, perhaps five, years ago, these questions could not even have been posed, let alone answered, in this country.

Admittedly, some of them cannot be answered with finality even today. But the answers to those that can be, and there are many, already furnish the basis for a serious, informed and critical discussion of the subject. The limits to such a discussion, it is now clear, will not be set by a lack of critical orientation, itself deriving from a ready acceptance of the sanctified states accorded to the nuclear programme by the state and the dominant interests and body of opinion associated with it. They are more likely to be determined by the quantity and quality of nuclear information, both controlled by those who have a vital stake in the programme and its expanded perpetuation.

II. The Theology Of The Atom

On May 9, 1983, The Times of India carried in all its three editions a front-page report which showed that workers at the Tarapur Atomic Power Station had been subjected to radiation exposures much in excess of the permissible levels. The report claimed that the Tarapur plant had broken "several world records" in radioactive pollution and exposed more than 300 men to doses exceeding the five-run (a unit of radiation, see box) limit.

On May 12, Homi Sethna, then chairman of the AEC and principal secretary to the government of India in the DAE, called a press conference in Bombay in response to the story. He did not deny the substance of the report or the specific details of exposure mention in it; but claimed that the doses of gamma radiation received by TAPS workers were not "harmful". At the end of a grilling two-and-a-half hours long discussion, during which the DAE was on the defensive, Sethna conceded the demand advanced by some journalists that workers radiation exposure records should be opened to the press, provided "no damage suits are brought against the DAE by the affected workers on the basis of that evidence".

This was a major concession and equally, an admission of guilt by the DAE, for the first time in public. More importantly, it brought into the open a part of what nuclear critics had long held to be the DAE's culpable safety record. It also rendered visible significant cracks in the whole structure of ideas and attitudes that sustain the basic justification for the atomic power programme.

This complex structure is what might be, for want of a better

team, be called the theology of the atom. The theology is a system of ideas, formulae and assumption strung together by a few but usually d facts, calculated to "prove" the inevitable necessity, desirability and safety of nuclear power. It maintains that nothing is wrong with nuclear power, for nothing can be. Failures, snags hitches and setbacks can only be minor or transitory because the viability success and the supremacy of the technology is given in its very essence, its basic character. The theology is the total justification for nuclear power. Nuclear powercan pose no environmental problems without at the same time (or in advance(solving them. The theology declares all problems solved. The atom is all powerful. The atom is all.

The theology goes right back to creation itself -- the birth of the first application of nuclear science in the form of the bomb that was dropped on Hiroshima on August 9, 1945. Later that year, a group of experts met in the U S to discuss the possibility of generating power from "controlled nuclear chain reaction units" as had termed atomic reactors. It was instantly declared viable.

In ten than two years the concept had reached Indian shores through the agency of Homi J. Bhabha. By 1948, years before the first uranium-burning commercial reactor had even been built anywhere, the idea had produced India's atomic Energy Commission. The Atom had been declared to be the ultimate technology, the key to India's nation-building project and the basis for its scientific , economic, social and cultural development.

The potential that atomic fission holds is indeed great, even

awesome. The possibility of fission power lies in the circumstance that beyond a certain limit heavy atoms are unstable and constnatly decay or transform themselves into different elements by releasing excess energy or particles such as neutrons, chargeless particles from their nuclear. Uranium is one such element. It exists in nature as a mixture of two isotopes (with identical chemical properties) but with different atomic weights), U-238 (99.3 per cent) and U-235 (0.7 per cent). U-235 has a peculiar characteristic it is "fissile", When it is bombarded with slow neutrons (see box), its nuclear breaks apart into two or more piece to the accompaniment of the release of a few neutrons. These in turn cause other nuclear to break up.... releasing more energy and thus a chain reaction can be set off to produce enormous quantities of energy. Where lies the possibility for both the nuclear reactor and the bomb; the chain reaction is, theoretically, controlled in the first, but not in the latter.

Thus, if only sufficient quantities of the right kind of uranium atoms can be procured and put together, huge quantities of energy can be generated, which can be tapped by says water to produce steam which in turn drives a turbine to generate electricity. This is the reactor. It typically burns either enriched uranium (in which the proportion of U-235 has been raised to 2 to 3 per cent from 0.7;) or even natural uranium provided, in the latter (called "moderator")
case, that the medium/in which the neutron-nuclear collision takes place does not absorb too many neutrons while slowing them down. Gräphite and heavy water are just such moderators. To return to

Uranium, it is not an uncommon constituent of the earth's and has an average abundance of 3.4 ppm. Ergo, it should be possible to generate huge quantities of power by burning uranium in reactors. What is particularly promising about all this is that the fission reaction generates products (such as plutonium-239) that themselves fissile. If there can be recycled, are and if other "fertile" materials can be made fissile and put back into reactors, it should be possible to generate virtually unlimited quantities of power. A magnificent prospect that, almost miraculously bountiful.

But it is shot through with some violent contradictions, many untractable problems.. and most important, with radioactivity all the way. Consider the nuclear fuel cycle. It runs from the mining and milling of uranium its refining (and aout 95 per cent of the world's reactors, enrichement and fabrication into fuel, through the use of the latter in a reactor, the refuelling of the reactor core and the removal of products of fission, to the separation and storage of waste (both temporary and long-term), reprocessing of spent fuel, decommissioning of nuclear facilities and their (half-way back to) the re-use of reprocessed fissile products in the reactor.

At each stage of the so-called fuel cycle, radioactive material is transported, or cowerted,refined, consumed, reacted, relocated, upon, concentrated, or evaporated or cooled or reshaped. Each single move, each distinct operation in the cycle, transports or concentrates or relocates radioactivity. Radioactivity spreads by contact and has a tendency to spread outwards from the notional

confines of the nuclear fuel cycle and into the environment and the biosphere. Radioactivity is a perverse analogue of the Midas touch. Like the fingers of King Midas in the myth, the touch of radioactive materials spreads radioactivity. To put it simply, space cannot confine it not in the real world of the fuel cycle. Only time can reduce it. But in the case of many materials, it takes tens of thousands of years before their radioactivity is reduced to half of its original level. T

That is not all. Typically, the closer one gets to fission and its products within the cycle, the higher the concentration of radioactivity in the nuclear equipment or materials, greater the risk, and the magnitude of the problem posed to technology, the higher the cost of handling or doing any of these operations, and the greater the risk of environmental pollution through contact with radioactive substances. Also, one might add, the greater the temptation to compromise on environmental or human safety in order to contain costs or abridge complex operations.

But the problem is by no means limited to the "hotter" segments of the fuel cycle. The interaction between the nuclear fuel cycle and the environment, leading to an adverse effect on the latter, starts right at the beginning, with the mining and milling of uranium.

Internationall, uranium is mined as an ore usually containing over 0.1 per cent of U3O8, some 3.4 lakh tonnes of the ore are estimated to be required to generate 1000 MW of power each year

in light water reactors of the Tarapur type.

India's exploitable uranium deposits are located primarily in the Singhbhum thrust belt of Bihar, and also in Rajasthan, M.P. Himachal, U.P., Ksrnataka and Meghalaya. But the bulk of the total indicated and inferred resources of 77,0000 tonnes of recoverable U308 are in low concentration grades (0.04 to 0.66 per cent). Of these some 16,000 tonnes constitute immediately exploitatble resources. (Another 10,000 tonnes could be recovered from the monazite deposits of Kerala, apart from some 14,000 tonnes as a by-product from copper tailings).

The most significant radiological hazard in uranium mining is represented by radon and its daughters (decay products). Following inhalation of radon gas and its daughter products in uranium mines, the alpha-particle e daughters irradiate the tissues and cells of the lung and respiratory tract. This is known to increase the incidence of cancer among the miners. Some smoking miners in the U.S. have shown an incidence of lung cancer up to ten times higher than that among non-smoking uranium miners. At a independent recent study (Mr Thomas McNeill), commissioned by Canada's Atomic Energy Control Board, of uranium mining in a number of different environments, shows that low-level radiation from various sources, includes radon, combines, with smoking, dust exposure and age to increase the chances of lung and other cancers sharply. As many as 16 out of every 100 miners have a high probability of dying from cancer if they smoke -- this in spite of some minimal precautions that the mine safety rules dictate in the countries surveyed.

In the uranium mines of Jaduguda, in Bihar, no such rules apply. Most do not even exist.This, the low concentration of the ore, the generally poor health of the miners, the low nutriotional standards prevalent in the backward region that Jaduguda is, and the fact that some of the uranium mines are known to have significant levels of gamma radiation, all suggest that the harm caused by uranium mining to DAE personnel is likely to be much greater. The subject remains to be in restigated a greater length, but such evidence as there is points to that conclusion. The DAE's safety practices in uranium mining and milling are certainly open to question.

For instance, it is known that noy even a quarter of all DAE uranium miners in Bihar and M.P. wear dosimeter badges (to measure the radioactivity dose absorbed over a period of time) and that most of them have never heard, of or seen, protection or shielding equipment.

This acquires particular importance in view of the fact that the DAE has been doing a good deal of exploratory and developmental drilling in various parts of the country — approximately 50,000 metres a year of the power former, with some deep-drilling in Madhya Pradesh and Himachal. Most of this work is done by contract workers who are not even warned of the possible risk from radon, radium and other toxims.

The reflect on the environment of uranium mining and milling in Bihar is far from inconsiderable. In the Jaduguda uranium mill, the ore is processed mechanically and chemically

(acid leaching) to extract the bulk of the uranium content to yield an unique concentrate of oxides called yellowcake. The mill tailings are dumped into a 25 hectare pond (A 1000 MW capacity nuclear programme annually produces about 3¼ lakh tonnes of tailings). The tailings are and the fluid is channellised into a nearby nullah. To this is also added the discharge from the mine. The mine water is found to contain 300 mg./m^3 of uranium 1110 Bequeral/m^3 of radium and 3 grams/m^3 of maganese.

The effluent 50 metres downstream from the tailings pile contains radium, manganese and sulphate above the derived water concentration. Bythe stage, the effluents reach Subarnarekha river, the chloride concentration in the aquatic system has risen by 140 per cent to 9.1 mg/litre and the uranium and radium concentration have both increased, the former by 2½ times to 3.2 mg/m^3. To this are added tailings from a nearby copper plant.

Even at sites 10 km. away from the plant, grass and milk ample show the presence of radium which has gone into the aquatic system.

The slurry collected in the tailings ponds has occasionally flowed into the nullah, thus compounding the problem. According to AE health physicists stationed at Jadu guda, all these recorded levesl fo concentration are below the permissible limits. This may well be the case, but the occasional discharge of the tailing slurry from the pond, directly into the acquatic system shows how precariously balanced the entire effluent treatment and discharge system is. The validity of the standards of the so-called permissible limits is far from settled. For the most part, the standards

are based (see P.) on arbitrary presumptions favourable to the nuclear industry. It is industry itself which has set them.

This raises a more general issue that has often figured in the assumption made by nuclear enthusiasts about the "safe" nature of natural or background radiation, such as in present in mines or deposits containing uranium. In publication after publication of the nuclear power establishment all over the world, the assertion is repeated that "there is no direct evidence of radiation - induced genetic defects in man" and that natural background radiation, (globally about 100 millirem a year), is not known to be harmful in any way, even where it is higher than the global average value.

There is however fairly persuasive evidence to show that high natural background radiation is correlated with genetic damage and cancer. (Note)

The Kochu Pillai study observed some radiation related genetic changes in coastal Kerala the location of monazite sands, where the background radiation is 1.5 to 3 runs per annum — much less than the levesl considered altogether safe and acceptable by the nuclear establishment.

But that returns us to the theme of the atomic theology. It ordains that the definition of safety does not disturb the nuclear dream.

IV. Low Level Radiation: High Dogma

Overexposure of occupational workers to radiation doses in excess of the declared permissible limits (fortnightly, quarterly, annual and lifetime) is by no means a rare occurrence in the nuclear industry. In every country with a sizeable nuclear programme, over exposure has been recorded time and again. In India's DAE, it is a hardy routine. But DAE officials deny that it is of any consequence so far as to workers' health is concerned. The denial is part of the nuclear dogma which holds that there is such a thing as safe level of exposure to ionising radiation. The nuclear industry proceeds, as has always proceeded on the assumption that so long as a person does not exceed this level, the threshold, no harm will result from exposure or that the damage will be repaired as fast as it is produced. Thus if a worker absorbs the permissible level of 5 runs a year, no adverse effects will occur. "No harmful effects can be detected at this level. This theory, recently modified a little to allow for "stochastic" effects, (those for which the probability of an effect occurring, rather than its severity, is regarded as a fraction of the dose) is the substructure upon which the nuclear industry's standards for radiological protection rest. It is part of its article of faith that such levels of radiation exposure as do (and must) exist in most nuclear plants are harmless. They can do no damage. The DAE's casually callous attitude even to cases of exposure exceeding its own norms arises from this faith. For most nuclear scientists and engineers tend to believe, as part of the atomic theology that radiation is fundamentally harmless

(except in very high, semi-fatal doses exceeding 50 or 100 runs), just as it is a fact of life. This it is that the "maximum permissible limits" are in practice flexible, and can be stretched on the exigencies of nuclear plant operations. In reality, however, ionising radiation is among the worst of poisons and an invisible hazard everywhere in the nuclear industry. It has both somatic and genetic effects on human beings, that is it produces cancer and irreversible genetic deformities. And, most important, there is an overwhelming account of evidence to prove that there is no safe level of radiation exposure at all. No dose of radiation is so low that the risk of cancer is zero. Radiation in all doses is harmful.

To quote Karl Z. Morgan, a founder of the science of health physics and former chairman of the International Commission on Radiological Protection and the U.S. National Council on Radiological Protection, "there is never a complete repair of the radiation damage, since ever at very low exposure levels, there are many thousands of interactions of the radiation with cells of the human body."

For example, one rad (roughly one run) of X-rays corresponds to 2.2 billion plutons per square centimetre acting on the body. "It is inconceivable that all the billions of irradiated and damaged cells would be repaired completely or replaced." When radiation passes through the human body, it is liable to damage the nucleus of a cell (which is a library of information), in such a way that the cell survives and multiplies in its distorted form over a period of five to 70 years, generating a clone of cells

that is eventualy diagnosed as a malignancy (cancer).

The risk of developing in malignancy varies from person to person, and differs with the type of cancer, age, sex, genetic inheritance, individual characteristics and eating and smoking habits. Thus Irvin D.J. Bross has shown that children with allergic diseases (e.g. asthma) have 300 to 400 per cent increased risk of dying of leukaemia than other children, those who received in utero diagnostic X-ray exposure have a 40 to 50 per cent increased risk of death from leukaemia;But those with both (X-ray exposure and allergic disease) have a 5,000 per cent risk of dying leukaemia.

Typically, radiation combines synergistically with other factors to wreak havoc on human health. This is as true of low-level doses as any other. The most substantial evidence of the carcinogenelity of low-level radiation comes from three studies. The first of there is the largest ṕ epidemiological study of radiation workers, at the U.S. government's plutonium production plant at Hanford (Washington, made by Thomas Ma , Alice Stewart and G. Kueale.

The background to the study itself reveals a great deal.

In 1974 Dr. Samuel Milham, a physician and epidemiologist working for Washington State discovered excess cancer mortality for men who worked at the Atomic Energy Commission Hanford facility in Richland, Washington. He noted an excess for cancers of the tongue, mouth and pharynx, colon, pancreas, lung and bone. He had analyzed 842 death certificates of Hanford Project Employees and discovered a 25% cancer excess in the years 1950-1973 in men

aged 20 to 64 at death.

The Atomic Energy Commission (AEC) rushed forward, but not to take steps to protect the workers, The AEC instead urged Dr. Milham not to publish his findings. They asked him to defer to the work of Dr. Mancuso, who had been organizing data on the Hanford workers under contract to the AEC since 1964. While they were successful in dissuading Dr. Milham from immediate publication, they did not succeed in their efforts to have Mancuso formally refute Milham's findings.Dr. Mancuso traced worker deaths through their social security numbers. When families of the former Hanford workers applied for death benefits, Dr. Mancuso would trace the cause of death through the death certificates. Dr. Mancuso could match information about the cause of deathwith the worker's radiation exposure history. (American workers are measured for their exposures to radiation, unlike the atomic bomb survivors, whose exposures were merely estimated.)

Dr. Mancuso told AEC representatives that he would not sign a press release discounting Milham's findings, since Milham might be correct. Although Mancuso had not uncovered any cancer patterns at that point, he realized that the social security method allowed considerable time to elapse before the deaths could be incorperated into the study data. Milham saw the evidence earlier than Mancuso, so his findings could be correct. When Mancuso refused to cooperate with the AEC effort to discredit Milham's findings, theAEC initiated the termination of funding for Mancuso's research.

Despite the termination of funds in 1976 and governmental

efforts to confiscate Mancuso'sdata base, the Hanford study was continued through private funding while Congressional hearings revealed the government's attempt to cover-up the findings of cancer increases at low levels of exposure.

Even the researcher hired by AEC's successor agency, the Energy Research and Development Administration (ERDA), Ethel Gilbert of Battelle Northwest, had to admit there was excess cancer at Hanford. This report was suppressed. Dr. Mancuso's data has been circulated by the Department of Energy to several critics, and they too have found excess cancer.

The study clearly reveals that the doubting dose for multiple myeloma, a narrow cancer, is only 4 rems -- i.e. the incidence of the disease doubled with a cumulative dose lower than the currently specified annual exposure limit. The doubling dose for sensitive cancers for (lung, pancreas, large intestine) a man of 40 was 14 to 15 rems. The commonest interval between induction and death was 25 years. The cancer risk increased progressively with adult age. Six per cent of all deaths among the 35,000 workers surveyed were attributable to radiation.

In another study, a preliminary work by Najarian and Cotton found that workers at the Portsmouth Naval Shipyard (which handled nuclear materials) showed a 450 per cent higher death rate for leukaemia than the general population. The cancer incidence was especially high among older workers. The study showed time as may lung cancers as expected -- with one rem or higher exposures.

According to Carl Johnson of the Jefferson County Health

Department in Lakewood, Calorado, a large area of land and Jefferson County has been contaminated with radioactive plutonium, which was released from the Rocky Flats Nuclear Weapons Plant. The contaminated region, which is near Denver is highly populated. Almost 150,000 people live within 10 miles downwind of the Rocky Flats plant.

Some of the release was the result of emissions of permissible quantities of ~~pu~~ plutonium, but most of it occurred as a result of a fire at the plant in 1957 and because of leakage from barrels of contaminated oil stored by the plant. Johnson says the plutonium concentrations in some parts of Jefferson Country are more than 3000 times higher than the background plutonium concentrations produced by nuclear fallout. Some plutonium isotopes are extremely long-lived; plutonium-239,#for example, has a half-life of 24,000 years.

Johnson now finds higher incidences of cancer among people living in the contaminated areas. He obtained his cancer incidence data from the Third National Cancer Survey conducted between 1969 and 1971 under the agis of NCI. Johnson says there appears to be a direct association between the plutonium concentrations in the soil and the increased risk of cancer. The increases in cancer incidences ranged from 6 per cent in the areas with the least contamination of 16 per cent in the area with the most contamination. Among the cancers showing increases were leukemia, lung cancer and cancer of the nasal passages and larynx. Johnson thinks that inhalation and ingestion of plutonium in dust are the most likely routes

by which the material enters the body. Jefferson County is a dusty, arid region having only about 8 inches of rainfall per year.

Johnson points out that the plutonium concentrations in most of the contaminated regions are still only about one-hundredth of the maximum permissible concentration proposed by theEnvironmental Protection Agency for limiting plutonium, contamination in residential areas. Johnson has written EPA administrator Douglas M. Costle to request a public hearing on the adequacy of the proposed standard. The EPA has declined this request on the basis of its having held a public meeting on the issue last year in Colorado.

Two studies have now implicated radioactive fallout as a cause of an increased risk of cancer, primarily leukemia, One study was carried out by investigators at the Center for Disease Control in Atlanta. It includes more than 3100 men who participated in 1957 in a nuclear weapons test code-named "Smoky". Most of the men at the Smoky test were exposed to less than 5 rads of external radiation, according to the exposures monitored by their film badges.

Analysis of the data is not yet complete but so far eight cases of leukemia have been found. Fewer than four would be expected in a group of men of that size and age range. Glyn Caldwell of the CDC, who is in charge of the study, considers this finding to be suspicious, but he cannot be sure about its significance until all the data are analysed.

The second study includes children living in Utah who were exposed to the nuclear fallout from weapons tests conducted in the

Nevada desert between 1951 and 1958. Joseph Lyon and his colleagues at the University of Utah College of Medicine compared the leukemia death rates in the parts of Utah that received high fallout doses with the rates in areas of the state subjected to little fallout. The rate did not change in the low fallout regions between 1944 and 1975 but it more than doubled in the high-fall-out areas between 1959 and 1967. Afterthat it declined to about the same value it had been before the weapons tests began. The findings imply that the radioactive fallout caused a temporary rise in leukemia deaths in the high-fallout countries of Utah.

Some other studies have shown that the accumulated dose for leukemia can be as low as 0.8 rem and for thyroid cancer (resulting from x-ray therapy of the scalp for ring worm!) only 6.5 rem. This 0.8 rem is only about a fiftieth of the 42 rem permitted by ICRP each year to the active bone marrow of radiation workers. And the 6.5 rem is less than a seventh of the "safe" dose permitted for thyroid!

Basing himself on a 1980 study (Biological Effects of Ionizing Radiation committee, B EIR III of the National Academy of Science), Edward Radford has argued that cancer a two rem per year dose increases the life-time risk of cancer by 8 to 11 per cent among men and 18 to 36 per cent among women.

Individual workers exposed to 5 rem a year from 18 to 30 years rem a 1 to 16 chance of a serious genetic risk. And cancer can be observed at doses as low as 2.5 rems a year.

To take yet another indicator, if a million children are

posed to a none rem dose in utero, some 300 to 6000 malignancies
e likely to result.

The examples can be multiplied. It is plain that the weight of
l this evidence -- and more and more is pouring in every year -- is
erwhelming. It is impossible not to be pursuaded that low level
nising radiation is harmful and that cancer incidence is bound to
se significantly, if not sharply, even at the so-called maximum per-
ssible dose limits.

All the accumulated evidence leads to the conservative estimate
at one rem of ionising radiation means a risk of 6×10^{4} cancers.
at is, a total of 10,000 man-rems of exposure can be expected to
oduce six cancers.

Partly under the weight of the evidence of hazards from low-level
diation, the U.S. Environmental Protection Agency (EPA) has reduced
commended exposures for people living near nuclear facilities to
025 rem (25 millirem) a year from 0.5 rem (500 millirem) less than
years earlier. And the U.S. Energy Research & Development Admini-
ration has recommended an even lower limit for the public at 0.005
m (5 millirem) a year.

The nuclear diehards, however, are neither willing nor able to
cept this evidence. They continue to raise feeble objections, metho-
logical questions and bizarre queries -- much like the Church did a
ng time ago when confronted with evolution. Their only point of
ference and sole source of sustenance, beside the theology of the
om, is a highly unsatisfactory study of mortality among the survivors
the atomic bomb in Japan.

Atomic bomb survivors were exposed to high levels of radiation
er a short period of time. The combined factors of blast, fire,
auma, disease, and deprivation of food and shelter contributed
the highly mortality rate after the bombing of Hiroshima and
agasaki. Those who managed to survive were not member of an average
typical population, but

strongest and fittest from among the cities' occupants. Unlike U.S. radiation workers, the atomic bomb survivors suffered high e destructive doses with resultant damage to organs -- most ly the bone marrow. Atomic bomba survivors do not represent an age or normal population, so conclusions drawn about them will dequately protect an average population .

The Life Span of Japanese atomic bomb survivors used early nts to Hiroshima and Nagasaki who were exposed to low level tion from fall-out and residual radiation as the control group, ad of a group not exposed to additional radiation. Dr. Rotblat a much higher cancer incidence among early entrants than the survivors who had weathered the shock of the bomb as well other traumas. The high doses of radiation may have killed that would otherwise have been sufficiently damaged that they later cause cancers. This cell killing effect coupled with the of those with weaker immune systems may account for the r cancer rate among the group exposed to the lower level of ion. The effects of a high dose of radiation over a short eriod probably do not predict the effects of low doses over period of time, since different bodily defense mechanisms obably at work.

here can thus be little doubt that the Japanese data greatly stimate the risk of radiation induced cancer and gentic . The other, weak, supplementary evidence the nuclear dichards n, greatly flawed by inadequate follow up periods of human s, forced extrapolation from data of overkills at high doses,

rom animals to human beings, or from disease-free inbred
ls to those in their natural state. Most such studies also
to take into account the heterogeneity of human population
he crucial difference between old and young people, in drawing
, but inadequately supported, conclusions from scanty data.
nstance, the natural resistance offered to radiation by an
rfed worker from a developing country, who weighs just 50 kg.,
be much lower than that put up by a white American weighing
. Equally, older people have a higher proportion of abnormal
in their body than do the young.

n sum, the little hard data (arch of whose representative
cter is open to question) on which the nuclear advocates
their assertions of safety, is fatally flawed. So are their
usions, although it must be granted that not all of those
erived from the data; some are a direct consequence of the
ogy.

The sheer s of the nuclear lobby and its scientific
gists, included those in the ICRA, is however far from uncha-
ristic. Nevertheless, in spite of the stiff resistance put up
e lobby, the maximum permissible level of exposure for occupa-
workers has dropped by a factor of 10 and/for the public by
tor of 300. This is a tacit, reluctant and belated recognition
e strength of the nuclear opponents' case.

It however raises another problem: that of egnity. It is
anomalous that the recommended exposure standards for the
and the occupational workers should differ by a factor as

as 10 or (in the U.S.) even 200. It is patently absurd to
ure that a radiation worker is 200 times less susceptible to
ation damage than other member of the population. It is, on the
hand, an acknowledged principle of law and that no one should
r deprivation, disadvantage or disability purely on account
particular choice of employment or occupation as a nuclear
r.

The only national thing to do would be to reduce the workers'
ure limits by a factor of ten or more. For continuing research
kely to show the need for even further reductions.

But the ICRP, and with it the DAE has done just the
ite. In its publication (26), ICRP has sought 15 reverse this
.

In a document that purports to merely standardize formulas for
ing risks to organs from internal radiation exposure, the
recommends changes that would increase radiation exposure to
ive organs in situations where radionuclides are deposited
organ alone. For example, use of the ICRP recommendations
increase radiation exposure to the lungs from 15 rem under
rrent standard to 42 rems. They would increase breast exposure
5 rem to 32 rem, and red marrow from 5 rem to 42 rem.
exposure would rise from 5 to 20 rem. Bone and thyroid expo-
ould escalate from 39 rem to 167 rem:

his recommendation can only be described as appalling. At
here is the validity of the 22 year old 5 rem limit for
body exposure. In 1959, when this limit was adopted, the

ing data consisted or studies on animals, fruit flies and
vidence on atomic-bomb survivors. The DAE's primary justi-
n for upholding the 5 rem limit in 1981 appears to be
from the high dose human studies -- most notably the atomic
rvivor studies.

it disgraceful that the DAE and ICRP should continue to
eir exposure limits on questionable and obsolete studies
ta on radiation workers shows that fatal cancer risks among
e 10 to 30 times greater. But it is not altogether surpris-
r it is both expeditions from the point of view of the
programme and in full conformity with the dogma. At the
me it reveals a perversity in the logic and method followed
nuclear industry: the exposure norms are neither set on any
fic basis nor rigorously determined <u>prior</u> to the routine
ular exposure of a growing number of workers. What is at
re is the idea that the standards can somehow be founded
out or verified later, some time in the future, meanwhile
must go on, for nuclear power is all important. It justi-
e search for export facto justifications for arbitrarily
ms or, in the absence of these, a mere assertion of dogma.

Kamadhenu Or White Elephant

The Man-rem costs of Tarapur Power.

Tarapur is without a doubt India's best performing nuclear
er station. It generates power at less than half the cost of
lear electricity produced at the other two (or one-and-a-half)
mic power stations in the country: Rajasthan (RAPS) and Madras
PS, at Kalpakkam, near Madras, where the first unit with a
ss capacity of 235 MW was commissioned in the Second half of 19
3). It does generate power more or less regularly (albeit with
apacity utilisation of about 40 per cent), unlike RAPS, which
s go somewhat rarely and MAPS which is still to be stabilised
therefore remain something of an unknown. Tarapur was comple-
more or less in time -- the delay was only 8 months on a
dule of 52 months -- unlike the other two stations: RAPS-I
delayed by four years, RAPS-II by eight years and MAPS-I by
t ten years (MAPS-II has already stretched the schedule by
t years and lies beyond the realm of rational comment or
iction.

Tarapur is, also without a doubt, the world's worst perform-
nuclear station. It remains the most polluted atomic power
t in the world, at least going by such data as is available.
l all the other reactors of similar design and vintage closed
, it generated between 25 and 45 per cent less power (per unit
enerating capacity) than them. Its costs kilowatt for kilo-
were the highest within this tribe, and five times higher

han those of the plant a Oyster Creek, in the U.S. designed and ompleted in the year. Tarapur has also had the distinction of eing the smallest and hence the most expensive per unit of capa- ity set of reactors built for a supplied to arny Third World ountry by the U.S. It remains one of the most grossly underdesi- ned and poorly engineered reactors traded anywhere. And the toll t extracts from its workers, measured in total man-rems, is the ighest known anywhere in the world in relation both to its altage and energy generation.

Tarapur is thus both an asset and a liability depending on hose point of view, one looks at it and the precise criterion used. For the DAE, Tarapur is a demonstrable example of the via- ility of nuclear power of the fact that atomic fission can and be nown to generate electricity on a sustained basis -- never mind the cost. For the U.S. government it is lever with which ontinually to keep India under pressure to sign the non-prolifer- tion treaty and agree not to reprocess the spent fuel from the eactor. For the plant's enginers Tarapur is a perennial and often ntractable web of technical problems. For its workers it is an un- nding purgatory of radiation. For the government of India, Tara- ur is a difficult choice, a diplomatic dilemma, a balancing act tween nuclear independence and "cooperation", between the compul- ions of the nuclear dream and the realities of power generation, tween prestige and pragmatism. For ordinary people who must bear e most of all such choices, Tarapur is an unmixed liability. d, it must be added, to the nuclear industry of western Europe,

ng starved of and now desparate for orders, Tarapur is a boon:
cording to a well-documented report (note) West German companies
e only too eager to hawk sub-systems of the scrapped Gundrom-
ngen reactor, also of Tarapur's lineage to the DAE as much need-
and publicised spares; the French are equally keen on exploring
clear export possibilities. (Evidently what is patently unsafe
d dangerous in Europe — KRB Gundremmingen was crapped in 1980
fety reasons — is perfectly safe, necessary and "state-of-the-
t" for India).

The Tarapur Atomic Power Station, designed and built by Gene-
. Electric subsidiary, represented a momentous development both
India and internationally. The two boiling water reactors (each
h an originally rated capacity of 190 M W, since ~~xxxxxx~~ arti-
ially uprated by the DAE to 210 MW) were part of a deal signed
1963 by Homi Bhabha with the U.S. government and ~~framed~~ financed
U.S. AID. The technology was part of what has been termed as
"Bandwagon Market" for nuclear reactors in the U.S. in the
ly and mid-sixties, just after the Oyster Creek reactor agree-
t was signed between the New Jersey Light & Power Co. and General
ctric, and atomic power was proclaimed to have arrived.

The Tarapur deal was also the first surrender bythe nuclear
ablishment of India to internationally dominant interests or
lers in the field. This capitulation, significant as negation
he idea of self-reliance and independence that the Indian atom-
nergy programme had apparently been founded upon, came on top
number of "tactical" retreats (See p- below) It represented

technology choice that would not only inaugurate but also perpetu- dependece on the U.S. (or a substitute supplier who would impose ilar, if not more onerous, conditions) for the supply of enriched anium fuel.

By accepting Tarapur as a turn-key job executed by general ction and its contractor, Bechtel, the DAE had missed the oppor- ity of acquiring familiarity with the tasks of designing, ctrical engineering, construction, testing and commissioning of power reactor. This was to leave a vital gap in the DAE's ability cope with the problems that began to flood TAPS, very soon er it commenced commercial power generation in October 1969.

The first of its problems, the switchyard, delayed TAPS' opera- n on base-load, i.e. a capacity factor of 80 per cent or above the minimal "design level" — by more than a year. When it did ch the level, in December 1970, it lasted for precisely four ths. That was also the last occasion it operated at the rated el for any stretch of time. But April 1971 one of the two reac- s gone Kaput. The other was operated far beyond the named sched- for the first ram and developed serious trouble. On inspection both reactors showed extraordinarily high rates fuel failure. What happens when a fuel candle fails? The cladding the fuel, made of zircalloy, gives way or develops leaks, thus lling out the highly radioactive fissile "meat" into the coolant s. Not only does it create problematic hot regions within the tor; the highly active material also spreads into at the coola- circuits with their tubing and valves and to steam generators,

densers and turbines -- the entire power station is quickly
taminated. Contact with the radioactive substances which form
erud" or deposit in vessels and pipes, renders the latter
ioactive produces new radioisotopes and undermines the integri-
of high temperature, high pressure equipment.

Fuel failure rates have been as high as 20 or even 35 per
at TAPS -- the "design level" being well under ten per cent.
major cause of fuel failure is unstatisfactory fuel geometry
reactor physics calculations. These constitute fundamental
fects in the reactor.

Fuel failure is a serious, but by no means the sole or even
most important, problem at TAPS.The station literally bristles
problems: steam generater tube leaks, recirculation pump
ures, control valve leaks, glands and valves malfunctioning,
ure of control rod drives, needed to regulate and shut down
reactor, numerous cracks in system piping, extensive corros-
leaking condenser tubes, and low vacuum in condenser, large
s in primary to secondary water line, inter-lie valve glands,
ore high flux, feedwater pump failures, and very important, nu-
rous failures of the electronic monitoring and control systems.
instrumentation. One of the most intractable but chronic pro-
s, generic to boiling water reactors such as TAPS, is what is
ed "intergranular stress corrosion cracking". Dogers of
m pipes, elbow joints, valves and welds are affected by this
dy. Leaks, with potentially dangerous consequences, are inevi-
in TAPS. Both the Tarapur reactors have for long been

actively "de-rated" to the power level of about 150-160 MW thank
rious design defects and operational problems, as well as extra
arily high levels of radioactivity in the station. This de-rat-
as been the real reason for the low power and energy output of
for the fast four years or longer.The DAE's explanation for
utput -- the need to "conserve fuel and stretch the fuel cy-
-- appears to have more to do with propaganda and its attempt
t enriched uranium supplies from the West, than with the reali-
or more details, see "Operating Experience With Nuclear Power
ons in member States", IAEA various years, Dhivendra Sharma,
a's Nuclear Estate" Ch.3, TAPS "Performance Report" various
K.P.Rao & K. Nanjundeswar & "Problems Associated with N.
nes at Tarapur, F1 75 TAPS/Report/1059. The list of Tarapur's
ems is tiresomely long. In a word, everything that could go
g her really gone wrong. Within a few years of operation, the
on had been so badly contaminated with radioactivity, that no
s was possible to the internals and even the casing of the tur-
-- the last stage of the power generation system. Everything
the alundry (which washes the contaminated clothing that
ntrants into the reactor building must deposit), through the
ar steam generation system to the non-nuclear electrical equip-
has been touched by radioactivity. In some cases even radiation
ers and counters are contaminated. This has made maintenance and
peration of the station extremely difficult as well as expens-
- TAPS engineers have for long been at the end of their leather
trying to cope with the numerous problems that arise from

deficiencies and equipment infirmities as well as procedural
an failures. The "Technical Specifications" handbook/manual
ed by G.E. as part of the turnkey contract had within a four
of start-up proved grossly inadequate in tackling most of the
problems.

The result was a spate of "unusual occurrences" (Nuclear Nus-
for fairly serious failures, emergencies and accidents). There
s many as 38 of these in the first five years of commencement
mercial power generation. By 1980, their number had reached
tounding 344. Contrary to what has often been propagated by
uthorities, the bulk of these "occurrences" have not been on
nt of external causes or procedural/human failures. As many as
r 74 per cent were due to "equipment or design deficiency".
Of these, as many as 128, or more than half, arose in the
ars, i.e. the nuclear system, not the non-nuclear ("conventional"
speak) system of the station. This settles the validity of the
repeatedly made by the nuclear industry that most of its opera-
problems are due to malfunctioning of the "conventianal systems"
ternal factors such as grid failures.

Currently an average of a little over five such "unusual occu-
es" take place every month at Tarapur. Here is an instance from
f what an unusual occurrence in unit I is: "Cracks on SS-304,
a. Emergency condenser steam line and 6" dia. Reactor recircu-
bypass line were observed due to intergranular stress corrosion
ing (IGSCC) and repaired. Repair of the reactor recirc. bypass
eak involved use of freeze plug technique for isolation." (IAEA

xperience, 1980, P.214). The report concluded: "Perfor-
e unit was satisfactory."

had happened was that defective weld joints on the reactor
ion loop bypass line showed up after most of the refuelling
it I was completed in mid-February 1980. This led to the
of the outage by another two months to repair the weld joints;
it was decided to carry out by using the "freeze plug tech-
isolation of the relevant portions of the line. The TAPS
chose this method rather than the normal one of unloading
e reactor core, apparently because the spent fuel pool in
core would temporarily be stored had no room for it.
quote an apparently reliable report, "a routine hydraulic
the primary coolant tube of the Tarapur nuclear reactor
e first week of March soon precipitated a major crisis. A
tdown was not just a theoretical possibility -- the horrors
hree Mile Island crisis loomed large in the reactor halls,
only by the vivid images of the "China Syndrome". A small
in hole!) was detected to the coolant tube. An immediate
was to remove the two feet long cracked tube and weld in a
e of pipe.
do this, however, is not easy. The primary coolant tube
hot radioactive water from the reactor core and a small crack
gh to drain out sufficient radioactive water contaminating the
a flash of a second. Slow but steady leakage would invariably
a fall in the water level of the reactor core, causing the tem-
e of the core to shoot up relentlessly. This would bring up

mperature to an awesome several thousand degrees -- the fission
pumping up the temperature even further. A core meltdown would
become inevitable. The standard procedure to check the outpour
radioactive water is to seal off the tube for a short while
old in the crack. The sealing in Tarapur was done by using an
plug" of liquid nitrogen, penetrating deep inside the tube, hope-
witholding the pressure of water for a sufficiently long time.
"The 'accident' on March 14 at 9 a.m. occurred when the 'ice
did not remain inside the coolant tube long enough and was pushed
y the gushing water, after the bad pipe was cut out and before
ew pipe was welded in. A temporary plug of a sort was then some-
ushed in and held in position by chains. The gush was controlled
he trickle wasn't. In the initial gush an awful lot of hot rad-
ive water came out on the hall floor, causing panic and hysteria.
evel of waterin the core by that time had already gone down, and
was the moment when all hell broke loose. By the time the gush was
ontrolled by plugs chained inside the tube the place was reeking
activity, at the same time threatening the core to gallop to a
on hot temperature. (The China syndrome was surely not far off!)
time check, some careless decisions, mistiming, lack of precision,
ghtly longer delay than allowed by a reactor handbook, within
es, can transform a simple routine job to a nerve shattering,
fying crisis, the magnitude of which, frankly, has no precedence
(Sunday, April 6, 1980). It has been claimed that the DAE got
of unskilled and illiterate labourers from a nearby village, and
them get into the highly radioactive water in order to retrieve

. No one knows that kind of radioactivity dose the men rece-
going by all that is known about contamination at TAPS, it
reasonable to conclude that it must have been very high, pro-
gher than the maximum allowed to occupational workers and
fold greater than the maximum permissible exposure for the
The DAE thus seems to have used thoroughly unprofessional
hical means in an attempt to control a disastrous accident.

e AEC chairman did not deny the main contentions of the report
arlier but claimed that the leak in question was of "pin-hole"
ns and of marginal significance.

This dreadful episode is probably not quite representative of e "unusual occurrences" that take place every six days on an erage at TAPS. But the fact that it did occur and is only one ong many known instances of overexposure of workers in the plant nothing short of scandalous.

Nor was this the first time that TAPS has used completely trained persons to work in highly radioactive areas. It is a gular routine. Till the end of 1982, a cumulative total of ,806 "temporary workers" had been used in the power station to o jobs in areas with high radioactivity fields. They received a mulative doses of over 1928 rems.

The number of such person working in the plant at any given me, and particularly during maintenance shutdowns, is usually tween 100 and 300. Onan annual basis, their number has risen om less than about 250 during the first few years of TAPS' oper- ion to between 1000 and 1500 currently -- or more than fenr-fold.

The DAE management has claimed that it is not an unusual actice in the world nuclear industry to use contract workers to ecute maintenance jobs; and, at any rate, that all such workers given adequate training in "mock-up" facilities (simulated work vironments)before they enter a radiation-infested zone. This, all those who have interviewed the temporary or contract rkers record, is simply unture. (Note)

The vast majority of the concerned workers have not the ggiest idea of the precise harm that invisible radiation can use.Many cannot comprehend the language in which instructions

given to them. And there is no such thing as systematic mock-up ning at TAPS.

In fact a recent DAE document mentions that the need for such ning precisely because it is absent: "Another significant deve- nt work ( ) that has to be initiated to ensure the smooth satisfactory operation of nuclear power stations is the setting the necessary mock-up facilities and training of personnel to rtain complex operations and maintenance jobs in nuclear power ions. This is needed because of the fact that the operating nnel doing any job for the first time... will take more time in the process get exposed to a certain amount of radiation..." th Five year Plan of the DAE, "R&D", submitted by the department e Planning Commission). Why does TAPS need to use such large rs of untrained workers to do maintenance jobs? The reason is erely that Tarapur is the world's most contaminated station, lso that the safety engineering techniques on which it is foun- re truly obsolete and antediluvian. The plant was designed ngineered in the early sixties -- way before the two major of design changes mandated by regulatory orders appeared in world nuclear industry: in the late-sixties to the early ties, and then in the post three Mile Island period. These egulations forced the industry elsewhere, particularly in the and northern Europe, to improve its safety engineering and ation standards.

TAPS remains desperately backward in relation to the contempo- standards. In any other country, it would be ordered closed,

s reactors of similar build and vintage have been scrapped
te of a record that is less appalling than TAPS.
uld the problem of contamination at TAPS have been solved?
amination measures might have produced some results decade
so, in Tarapur's early days. But there are really no proven
amination techniques which are either safe or economical.
ore importantly, any decontamination effort itself involves
f increased exposure from relocating radioactive material
nce man-rem costs. TAPS is now and has long been, clearly part
age where the risk would be matched by the benefit.
e radiation levels at TAPS exceed their design value by sever-
tiples and even orders of magnitude. For instance, near the
or (at height 200'), the design value of the radiation field
illirem/hour; in practice 6 to 8 millirem/hour. At C.U' pre-
ank (160') the two valves are 1 and 45.
t the C.U. recirculation pump (Unit I, 143'), the two values
and 1,280 (in one year 1,592). At the drywell unit I recircu-
times even a fortnight after shutdown) the values are one
millirem/hours. This means that the workers' fortnightly
sible dose is exhausted in less than 20 minutes. His annual
s completed in 4½ hours -- or a fraction of the time it takes
a repair job on the lines.
This is not all.The regen heat exchanges in both the units
on contact a dose of 10,000 to 12,000 millirem/hour. And
are many "hot spots" near the steam generators or in the

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ell or in the core, which the workers need to reach, where field is in excess of 1000 rads an hour.

The workers will receive a fatal or quasi-fatal dose here a matter of minutes. In keeping with thequality of the plant, DAE management has over the years become unconcerned about n callous towards safely. It sees the expended man-rems not as cal cost but as a means to saving money costs. Thus it has in-ased the total man-rem exposure from an average of under 500 ms a year in the first three years of TAPS' life to about 5,000 s a year currently.

The average dose of the TAPS employee has increased from 117 llirem in 1969, thrcugh 359 millirem in 1970 and 2,990 millirem 1974 to a frightening 4,069 millirem in 1982 — a 35-fold in-ease in 13 years.For the TAPS maintenance staff, the average posure was an even more alarming 4500 millirem in 1982. idently the strategy of the TAPS management has been one of most as the plant's workers with radiation doses just der the 5000 millirem maximum level, but of distributing the dose such a way that none of them exceeds the limit (in the past erexposures, of individual workers - 6.4 rem in 1972, 5.1 rem 1973, 6.1 rem in 1974, 7 rem in 1976, 16 rem in 1977, 11.3 rem 1979 and 5.1 rem in 1979 — had raised a stink and created ch restiveness among the workers.

As part of the same strategy the management has also expanded e base of radiation-exposure while increasing the dose. This, e number of TAPS employees charged with radiation duties has

sed from under 200 to between 800 and 900 — a four-fold
se. The management has also doubled its annual intake of
s from other DAE units (extending TAPS) to about 1100-1400
he past decade. — All this has happened in a period during
the energy output from TAPS actually declined.
ill the end of 1982, TAPS had delivered a total cumulative
f 45,163 rems. A little over half of this total, or 22,921
had been absorbed by TAPS employees, some 13,317 rems by
sfrom other DAEunits and the rest by temporary workers.
ing the rough but conservative estimate that 1 rem of ioni-
adiation exposure has an overall risk coefficient of 6×10^{-4}
s (or that 10,000 rems cause about six cancers), radiation
S can be expected to have already claimed 27 lives (till
d of 1982) although the deaths may not have occurred as yet.
nd for each additional year during which it operates, deli-
a total dose of 4000 to 5000 rems and probably more as it
TAPS will claim another 2 to 3 lives.
cumulative total of 34,161 persons have so far received
ion doses inside TAPS.This roughly equals the number of
in the Hanford populationStudied by Mancuso. It is worth
ng that the average radiation dose of the 442 Hanford
who died during 1944-72, the period of the Mancuso study,
y about one rem. The long-term consequences of this expo-
e too horrifying to comtemplate. If Mancuso even fascist
sitate to argue that a toll of 400 ~~lives~~ lives is justi-
the creation of 400 MW power generating capacity. Even a

ef glimpse at these numbers it should put paid to the DAE's
ety claims and its protestations of concern for workers' health.
e and for all. The man-rem costs of power generation must
ve as an important criterion for evaluating the desirability of
mic energy.They are the crudest indicator of the risk to which
iety is forcibly exposed on account of the existence of nuclear
er.They represent a major entry on the debit side of the atomic
ial balance sheet. What does the DAE's shameful exposure record
ail for the real non-monetary costs of Tarapur power?

Tarapur's costs, measured in man-rems per megawatt year, are
obably the highest anywhere in the world. Today they stand at
out 100 man-rem per MW of capacity. In the U.S., to take one
mple, they are roughly 1.2 man-rem/MW. Between1969 and 1980
collective dose of reactor rose in the U.S. from 178 man-rem
791 man-rems in the four-fold. In the same period, it increased
TAPS from 21.5 man rems to 2125 man rems — an almost 100-fold
crease.

Tarapur's collective workers dose per reactor is thus 270
cent higher than in the U.S. But the U.S. level is itself too
gh, on environmental considerations. Many environemtnalists have
manded a reduction in collective doses to 300 to 500 man-rems
large 1000 MW reactor per year. Karl Z. Morgan has proposed a
-rem budget of 0.5 man-rem/MW for existing reactors and 0.2 man-
/MW for plants under construction.

By these standards, TAPS is 200 to 500 times dirtier and more
pensive in man-rem tens than the munimal acceptable hazardous

ar reactor. Indeed, should even the less stringent of those
ards be applied to Tarapur, it would be forced to close down
ever. For radiation has become inseparable from power genera-
in that station. Nothing can be done, not even routine main-
ce jobs under shutdown conditions at TAPS without expending
acceptably large quantity of man-rems.

The U.S. Nuclear Regulating commission has recently set the
per man-rem at $1000. While this in some ways amounts to
ing a value of human life and has a questionable ethical
se underlying it, some people feel that it may in practice
as a mild penalty for high exposures and discourage them.
such a penalty measure be imposed upon Tarapur, the station
have to pay a fine of some Rs.4.5 crores of rupees a year
ch would add over 25 per cent to the cost of electricity
d by the DAE. This would not only wipe out TAPS's past and
t profits but also prove a fortion that atomic power can ne-
mpete even economically with electricity from coal-burning
roelectric stations. Theoretically, that is going by the
of those who designed and run it, Tarapur has still
r ten years to go. This presumes an absence of safety regula-
as well as resistance to them, the sacrifice of another 30
s lives — radiation levels can only rise with the age of
ant — and a capacity factor that is less than a third.(Note)

(Note) "Operating Experience" 1979, Tables II, VII & X for Boiling Reactors 100-599 MW).

or the DAE which is trying so hard to tie up albeit at one-

political costs fuel and spares supplies to feed TAPS
is obviously something of a meaningful target, if not a
enge if only because Tarapur is, as was said earlier, its
performing nuclear station and since there is no likelihood
the other atomic station will watch its power generation
rmance in the near future.

The choice to let TAPS run is much less simple for all the
s involved the workers, environmentalists, the general
o. It nevertheless has to be made.

AN ('T) DU: Rajasthan's Prolonged Agony

f only by default -- Tarapur grabs so may headlines — the sthan Atomic Power Station has rarely x received adequate c and environmentalist attention. Indeed, the emphasis on appalling records of radiation contamination and exposure at as tended to obscure -- and content to prevent from reaching limelight -- Rajasthan's own distinguished performance in the i.

This performance is by no means unremarkable. For a station has worked at about a third of its rated capacity, RAPS has quals in the rest of the world, irrespective of the kind of tor they produce their steam from, so far as health hazards go. s the worst performing reactor of the CANDU type. Where the U tribe's cumulative load (capacity) factor has been of the r of 60 or 65 per cent -- and even higher during their peak od -- there is no hope that RAPS' will reach even two-thirds hat. One simple reason for this is that the reactor in unit RAPS has all but broken down: its end-shield is cracked. Ther ittle likelihood that this critical component will be repaired hat the plant will rem even after some patchwork solution is cted. RAPS-I has had to be shut down 251 times during its 10 life-span, or roughly on ce every fortnight. RAPS-II has so recorded a pathetic capacity factor of about 25 per cent. sthan's power generation performance is the worst for any

lectrical station anywhere in the world. Megawatt for
t of installed capacity it generates less energy than any
uclear plant, new or old. Even in relation to the other
ed nuclear power stations in theThird World, RAPS's record is
eful. It generates less than half as much energy per MW per
an does the Argentinian plant, Atucha-I.Even S. Korea's
and the Pakistani Kanupp ~~exp~~s produce more electricity
year than does RAPS.

s roots of the trouble with both of the RAPS reactors go
ht back to Canade, and its first, rather awkward, attempt
mmercial nuclear power plant, Douglas Point near Kincardine
.

e 200 MW Douglas Point reactor project was launched in Septe-
60, to be completed at the cost of $81.5 million in 1964
rt commercial operation the next year. It took Douglas Point
ate 1966 to begin working and its operator, Ontario Hydro,
two years to overcome working problems and enter into commer-
rvice. "Even then, the station operated for only once of
st twelve months" (Note)
uglas Point has had an average capacity factor of under
cent, as against the expected 80 per cent. Power generated
plant has proved 170 per cent dearer than originally estima-

has had an questionable safety record. The emergency core
system has exceeded the targetted ceiling for unavailabity
ctor of 13 and thus failed to meet the plant's licensing

tion. According to Canada's Atomic Energy control Board, mergency cooling system at Douglas Point could not prevent failure (which could lead to serious accidents) even if it d. In 1977, it ordered a "de-rating" of the plant's power to 70 per cent of its capacity, as a safety requirement, and asked Ontario Hydro shut the plant down in 1980 to make modi-ons costing $5 million. Air leakage rates from the plant ng werealso found too high. It is not known if Douglas Point t with the AECB's approved as yet.

The Douglas Point design is the basis for both for reactors PS. Basically the Indian reactors are exact replicas of the an plant. The Canadians in fact built RAPS-I and a good deal PS-II.Rajasthan thus inherits all the major design deficiencies glas Point and all reproduces its problems in their complex ss. But, expectedly, some of the problems have proved such in the Indian station: heavy water leakage, to take one ce, has been five to eight times higher than in Canada. While s Point was completed with a cost overrun of just four nt, the figure for RAPS-I is 76 per cent and for its second ver 90 per cent! Unit one of the Madras Atomic Power Station in all its essential aspects is a replica of the RAPS reactors so had a cost overrun exceeding 90 per cent. The construction for RAPS II and for MAPS have also been well in excess ce the four year-spillover for Douglas point respectively and ten years. The warped and elongated construction schedules d serious difficulties for RAPS.While half or more of the

nd unit was complete, and waiting for its mutual charge of
y water, the station management started cannibalising it,
ting while sub-systems and vital components as a replacement
their malfunctioning or diseased counterparts in the first
. Inventory control went ragwice, operational schedules lost
r meaning, planning become impossible and mismanagement rampant.
this was to tell not only on unit two but eventually on the
t unit itself. The station management has failed to solve any
he serious problems that continue to plague RAPS: heavy water
es of 60 to 80 kg. worth about Rs.4 lakhs, a day, turbine
ure, malfunctioning of the fuelling machines, leaks in valves
glands breakdown of pipelines -- and not important metal
ure, particularly in coolant channels. The existence of
last problem was recently acknowledged by M.R. Srinivasan,
ctor of the DAE's power projects engineering division: "We
recently taken out a coolant channel from RAPA-I which should
ide as an opportunity for generating vital information. A
important question relating to coolant tubes is whether they
require one or two replacement in a 30 year life and whether
-niobium is in fact a better material than zircally?..."
lar questions have also been raised about the integrity of
on steel tube sheets in the end shields, under inadiation.
re is no reason to believe that most of these questions have
settled or solutions found.

The Indian reactors based on the CANDU design, the converstonic
his countryIs nuclear power generation programme, inherit anot-

ious problem. The pressure tubes (coolant reactor) that
e natural uranium fuel pellets ⌀ in the core start expanding
th. The allowance made in the design for this elongation is
ate. This is a major design flaw shared by all CANDU reactors
create serious operational problems, causing leaks or high
on fields, and making on-power refuelling difficult if not
ble. It may have contributed to the appearance of big
in RAPS-I's end shield five years ago. But no attempt
r has been made in the DAE to correct the serious flaws in
rowed point design. What makes the Indian experience
ANDU reactors worse and potentially more dangerous is the
e in this country of any safety engineering regulations and
rds for the performance of crucial mechanisms such as emergen-
e cooling, shutdown and containment system or even well defined
for operating practices. Given this void, it is utterly
urprising that large numbers of RAPS workers have been exposed
ards from both ionizing radiation and tritium. Tritium, a
isotope of hydrogen (atomic weight three) is a potent toxin
s a by product of heavy water reactor operation. It is
esent in and around RAPS reactor s and shows particularly high
tration in the atmosphere or light/heavy water whenever there
aks -- (These are of course routine, and can be as high as
llos per minute) Tritium is readily absorbed by the human body.
resence at several places in RAPS exceeds the maximum permis-
concentration (MPC) levels by several multiples. Four, 20,
500 yet the vast majority of workers in the station are not

ered to use protective clothing or masks. Often they are not
n warned of high levels of tritium contamination in specific
as of the plant.

In respect of Gamma radiation, the published record ofRAPS
equally bad. In1975 its total collective personnel exposure was
pproximately" 800 man-rems - perhaps the highest for any 200 MW
actor in the world, barring Tarapur of course. The following
ar RAPS personnel received "about 650 man-rems" and contractor
rsonnel 150 man-rems. In 1977, the station personnel received
5 man-rems and there was no entry againsg the item of "contrac-
r personnel" exposure in the IAEA prforma returned by RAPS. In
78, the total had reached 893 man-rems.

Some of these figures, those relating to the earlier years,
pear to be twoo precise and round, but that may be a coincidence.
at is certainly not a coincidence is that since 1978 there has
entry at all in the available IAEA interactive for radiation
posure at RAPS. This is precisely the period in which the end-
ield cracks in unit one must have led to extraordinarily high
diation levels(as well as increased worker exposure thanks to
pair efforts) and during which RAPS-II too came on live to
xpose its workers to fresh doses of gamma rays. The contamination
evels at RAPS can only increase with time. Even its present level
emain unacceptable high. If a reasonable man-rem ceiling, such
s 0.2 or 0.5 man-rem per MW of capacity is imposed on RAPS, the
tation would have toclose down permanently. If, as recent reports
uggest, the DAE does scrap RAPS-I, it will, regretiably, be for

eason altogether, viz, that the reactor can no longer

The Perpetual Radiation Machine

The Nuclear Fuel Cycle

Nothing -- not even Tarapur and Rajasthan with their alliocious
ation records -- exposes the DAE's contempt for humanand en-
nmental safety starkly as its decision to site the country's
th atomic power station at Narora, in western Uttar Pradesh.
Narora is situated in an earthquake-prone, active seismic
(grade IV), only 50 km. from the Bulandashar epicentre of
earthquake. The site is in a geologically unstable area, with
tear fault" close by. Narora is also on the bank of the Ganga
in the midst of a densely populated region. At the precise
ation where the Narora atomic power project is now being erec-
, the water table is only four to five metres below ground
el; there is no rock for a stable foundation; even at 300
tres depth (as against the usual foundation drilling depth of
metres), no senure, stable geological structure exists.
one is looking for an environemental nightmare that is poten-
ally even more frightening than Three Mile Island, then this is
. Who is responsible for siting the atomic project at Narora?
rtainly not the Vengurlekar Committee on its site selection, which
1972 interim report, had opposed the proposal.Certainly no
nvironmentalist : In fact, the one person who had expressed the
ost consistent about envrionmental issues within the DAE, A.K.
anguly, then head of BARC's chemical group, has been a vehement
ritic of the decision to locate the plant at that site.

It is the very top layer of the DAE hierarchy itself which arbitrarily took the decision, bypassing not merely environmental considerations, but also its own established procedures. It did not even wait for formal clearance from its own safety committee before proceeding to start digging at Narora. It has now half-finished digging what may well prove to be the grave of the eco-system of the Gangetic plain and perhaps of millions of people.

The DAE has not even a fig-leaf of justification for the Narora site. Its decision defies all logic, even that of survival. Let us put it bluntly: What happens if there are strong tremors or an earthquake in the region? Is there reasonable guarantee that the reinforced structures that are being specially designed to lend NAPP some stability will hold? What would be the consequences of a significant release of radioactivity into the Ganga? Can anyone, anything, ensure in case of an earthquake that large of land, huge volumes of water and several hundreds of thousands of people will not be sprayed with radioactivity from the heart of the plant when it becomes operational? Is not certain that even after it has exhausted its useful economic life of 25 to 30 years, NAPP will continue to threaten the surrounding environment with disaster. No construction, no structural components, no engineering material can be designed to withstand all manner of stress and retain its integrity and strength indefinitely. There are only short, finite periods such as 30, 50 or a hundred years about which some assurance exists. Not even the most reckless of geologists and engineers will certify a steel and concrete structure,

oundation and the formation on which it rests as stage and
le for hundreds or thousandsof year.

And yet, hundreds or thousands of years after its power genera-
capacity is exhausted, the Narora plant or its tomb, or its
ins will physically still be in its site, and still seething
radioactivty. Many radio-nuclides produced in fission have
-lives of thxxxxxxxx thousands of years. Take plutonium -239
a half life of years. U-235 has a half-life of 710
ion years. One crack in containment, a few leaks in piplelines
ving in of a support structure here or there will still spell
ster. What can a spill of, say, plutonium from the spent fuel
APP, or an explosive collapse of the plant caused by an earth-
e, lead to? Depending on whether conditions, 800,000 deaths (See
e) What if a small quantity of plutonium, such as a few ounces,
dentally spills into the Ganga? It could destroy the entire
tic life in the area and poison all its vegetation -- more
ctively and longer than could all theAgent Orgage used in Viet
-- and eventually get into the human food chain and cause tens
housands of cancer-deaths.

The cynicism at the root of the decision to locate an atomic
r project at Narora is indescribable. But it has its roots in a
y grandiose scheme, formulated 15 years ago, to set up anassive
tacular nuclear "agro-industrial" complexes in certain parts
he country to bring about their instant, large-scale, technolo-
l (and hence social) transformation. These nuplexes would
uce vast quantities of cheap power to run pumpsets, produce

ilisers, drive the wheels of industry, and fuel the engine of a
culous prosperity.

This was not a mere daydream, not just a private of cranky,
.. A masime project report was drawn up by DAE ~~secret~~ secretary,
am Sarabhai and six of his colleagues in 1970 ("An Agro-Industri-
omplex in the Gangetic Plain" ed. B.P. Rastoji).

Mercifully, the Nuplex scheme, was never translated into a
of action. It was quietly buried. However its ghost survives,
the twin reactors of Narora.

NAPP bears testimony to the power of India's science and tech-
ogy visionaries, her nuclear dreamers. The vision and its sheer
ep tends to outlive them.

The vision extends itself to the entire fuel cycle of nuclear
rgy, from uranium exploration and coming to fuel fabrication to
ctors to reprocessing and to waste disposal. Like the power
tions, most of facilities remain cemeteries/burial grounds for
hope of safety of nuclear power. From what is known of it,
ir safety record ranges from riddling to appallingly poor and is
each case composed of a serious of black marks. The nuclear fuel
plex at Hyderabad, where uranium is fabricated into fuel rods or
lets clad in metallic sheets, made the headlines in March 1982,
n two children died of burns from an explosion in the combustible
p from the plant, dumped in the open. A year earlier, a woman
three children had been killed and several others, including
e plant workers, severely ~~inj~~ injured. NFC was to witness yet
other accident later in 1982, on the 26th, in which an explosion

occurred in its zirconium sponge plant, apparently owing to negli_ gence in the monitoring of pressure gauges.The blast would have claimed several lives had March 26 not been a holiday for most NFC workers.

Gross negligence, sloppy industrial practices and callousness have combined at NFC to turn the waste ground, unguaranded and ~~unfenced~~ unfenced, into death trap. Worse, NFC has for years been discharging poisonous effluents through steam water drains, thus subjecting large numbers of people living in its neighbourhood to various kinds of pollution, including radioactivity.Water from wells and fields in a large part of NFC's environs has shown high levels of concentration of toxic substance. Belatedly, in 1976, NFC built settling tanks and effluent treatment facilities. This has however made not the slightest difference to the pollution levels.

A heart physicist's investigations revealed that the uranium concentration levels in well water had increased six to 20 times in a few years.

A group of environmentalists and physicians, who have surveyed some of the 3000 workers NFC say they revaled all the signs of being unprotected against the hazards associated with chemical plants, metallurgical factories engineering workshops as well as nuclear facilities. Despite its repeated efforts to be allowed to check the installations for safety and ~~xinix~~ singular monitor the effects of work hazards on the workers' health, the group has apparently failed to receive any serious response from the NFC management.

The Bhabha Atomic Research Centre is the prime P & D institution of the DAE. It is also the source of production of the department's safety standards, the headquarters of its health physics and radiological protection divisions and the cradle of all senior DAE staff. BARC is not an industrial or production facility like TAPS or NFC is, It has however had a shameful record of radiation exposure. It has subjected (at last count, till eight years ago) four persons to annual doses exceeding five rems and has a man-rem cumulative total that rems into at least four digits.

It ha also had the distinction of having registered the highe known dose that any DAE employee has received in an single year — 22.28 rems. That was more than ten years ago, and as recorded in figures published seven years ago. Since then, the statistics ha dried up but the radiation exposure has. So has the propensity of TLD (thermo-luminiscent dosimeter) and film badges to disappear, or be "lost", or to have their film "spoilt".(Note)
In the absence of the missing quantities of badges -- the only p manent record of the individual worker's radiation exposure — n one will ever know the precise toll of human health as claimed b BARC and the DAE. But that which is known points to a deplorable record.

The worst aspect of this relates to the plutonium plant at Trombay, that reprocessed the spent fuel from CIRUS to produce material which went into the Pokhran explosion device in 1974. (The plant was dismantled but is now being rebuilt in an expand form).

Besides gamma radiation, the hazard in the Plutonium Plant is plutonium itself -- the element named after the god of Hell, and the most toxic substance known to humanity so far (a few ounces can kill the entire population of the world). Among the people who have been exposed to this deadly hazard is KSD(49), who in 1986 was asked to go into the cell room and clean solid deposits accumulated in and around the cells -- without wearing a gas mask. KSD swept cell with a broom; the sweeping produced a dust cloud which "choked me." KSD was taken out, bathed "for two to three hoursxxxx with all kinds of chemicals," and finally ordered to have this head shaved clean of hair "in any barber's shop". KSD claims that even on repeated requests from him, no immediate body burden measurement for uranium, plutonium or any other substance was made instead, he was granted a promotion to the next grade, out of turn and "to my surprise", the whole case was "hushed up."

It is relevant to note that in its original avatar, the plutonium plant, designed and built by Sethna, had never been cleared for safety. For several years it was the most dangerously polluted site in BARC.

It is likely to regain the same status in its second appearance.#For reprocessing a spent nuclear fuel to recover plutonium is among the most hazardous, problem ridden and enviromentally dangerous parts of the nuclear fuel cycle. No plant built to reprocess spent fuel from reactors has worked for any length of time at even a figth of its capacity. Fun of the world's five

reprocessing plants with any history of operating experience been closed down, since they were grossly unsafe and accident . (Note)

Spent fuel reprocessing, a crucial step in the nuclear fuel , has not been proved to be technologically viable. It remains rously unsafe and frightfully experience. Rather than sub- ially reduce, as the nuclear theology would have it do, fuel and power generation costs, it adds anything between ent and per cent to the latter.(Note)

nvironmental consequneces of an in reprocessing plant n accidental spill of plutonium are altogether too horrifying, or leak could kill a few hundred thousand people. Reprocessing has also been a major source of proliferation clear weapons and the less expensive and easier of the two pal routes to the atomic bomb. Reprocessing plants the world ave long been notorious for wide discrepancies between theore- y predicted plutonium yields and actual ones. A great deal of ium that ought to be recovered tends mysteriously to dis- . The new reprocessing plant at Tarapur, PREFRE, is no exce- to this. Already some — kg. of plutonium, or roughly he quantity needed to make a bomb, cannot be accounted for

he destructive possibilities represented by plutonium repro- g almost pale into insignificance when compared with the te and rear permanent hazard of nuclear power: radiation tive waste. High-level waste, with a furious potential for

radiation lasting whole millenia, cannot be contained much less
liminated by any known technology whether developed, embryonic or,
s of new, conceivable. By its very nature, radioactivity cannot
e abolished, eliminated or neutralised. It has to work itself out,
ecay over a long period of time -- thousands, millions or billions
f years -- till it is reduced to insignificant proportions.

The problem is thus one of storing high-level wastes safely
ver an almost geological time-scale or cons. The nuclear industry
hich is beginning to discover where its Achilles' heel might l
ie and which is now compelled to acknowledge the importance of
he issue, has made it a habit almost a routine to announce periodi-
ally that it has found a solution to the problem of containing,
onfining or storing high-level radioactive waste and that a new
ethod has been developed which represents a genuine breakthough.
In reality, these claims one pure fabrications, the result of
ishful thinking or imagination. Not a single one of these "break-
hroughs" has been proved even vaguely or potentially viable, most
xist only on paper -- IAEA or nuclear lobby publications, often
or internal consumption and reassurance of the industry.

~~Bit-eveb~~
Not even the most fiercely loyal among the nuclear faithfuls
an claim that the waste disposal problem has been licked. The more
easonable amongst them do not even claim that it is anywhere near
eing licked; they hope and feel sure, however, that it will (here
gain is the substitution of hope for reason, that inevitable
consequence of the theology of the atom).

The only rationale, indeed, plausible, stand is that nuclear

power must be declared as unacceptably unsafe until the waste disposal problem is solved fully and satisfactorily. It is simply illegitimate to build what has been termed "a house with ~~#~~ no toilets"; the excrea are bound to be dumped on society. The worst hazard represented by high-level wastes is that wherever and however stored, they are liable to leak into ground water and the larger biosphere.

Even if they are mitrified, or turned into a of glass as the French and, after then, the DAE, are trying to do —, or stored in special "stable" disposal sites -- west Germany is trying to find these — or dumped into the sea or in Timbuctoo, they remain a grave liability, the heaviest that the nuclear business carries. Putting them into salt formations or deposits high up in the will not do, although these are meant to be relatively stable formations.

The point is "relatively stable" won't do. There is no quantifiable or reasonable guarantee that any accessible geological formation that we know will remain stable for millions of years, nor that it will not itself be affected by the high-level waste to be stored in its bowels.

No geologist worth lies or her salt will venture to give such a guarantee. High level waste ~~dxsp~~ disposal remains an intra-
made-made,
table problem. No/engineered material can have integrity or permanence or activity measured by the geological clock -- with the one of exception of radioactive nuclides. These substances cannot be contained or disposed of or eliminated by what has so far been the rule or the known limits of technology.The genie cannot

ettled. Should it be allowed to be created at all?

The problem of high-level waste disposal has mind-boggling nsions. Upto 20,000 tonnes of this concentrated poison exists he world today. Most of it is stored at power stations in spent pools -- "temporarily" but really for years.

The problem posed by so-called "low-level wastes is far from onsiderable. Their sheer volume runs into billions of cubic t. The dumping of these wastes -- ~~industry~~ including uranium lings, fuel fabrication wastes, tonnes of much discarded by er reactors each year, including contaminated clothing, etc. o shallow trenches or the sea is a major hazard. They are bound enter the food chain sooner or later.

What would be the cost of waste disposal? There is a whole ge of estimates from the 5.10 per cent spectrum to the 20 to 30 cent level (as a proportion of the ash of nuclear power genera- on). In the U.S. the utilities are charged $1 for every 1,000 KWH power generated towards the control cost of waste "disposal". is is considered very inadequate by environmentalists critical nuclear power.

In India, the direct price has so far been paid in man-rems d human life; the indirect money price will be, as it continues be, paid by the ordinary taxpayer though the public exchequer.

If a major component of the indirect costs of nuclear power oth in man-rem exposed and money terms -- a part of the total ocial subsidy for atomic electricity -- lie in waste disposal, ecommissioning of nuclear installations claims an even higher roportion of the total commitment. Society is called upon, or

ced, to make in order to sustain the nation also.

The decommissioning of old nuclear power plants presents ilar economic worries. The term "decommissioning" is a misnomer ce it implies a routine shutdown procedure similar to abandoning old coal mine. But nuclear plants that have been operating for ades have many parts that are radioactive and must be kept from biosphere for centuries. One approach is called "entombment" sealing a plant with reinforced concrete and providing guards r an indefinite period, But entombment, though possibly economical es unacceptable long-term environmental problems, particularly nce some materials would remain radioactive for as long as 100,000 ars, long past the useful life of concrete. Ensuring the integri- of human institutions of provide centuries of guard duty is also oblematic. Nuclear industry officials cringe at the notion of ndreds of nuclear "tomb" around the world serving as a reminder of e long-term hazards of nuclear power."

The more likely approach to decommissiong is dismantling each clear plant piece by piece, and transporting radioactive materials suitable waste sites.The technical difficulties involved are onsiderable. Because of the high levels of radiation that would be ncountered, elaborate safeguards must be used to limit human xposure. Some parts of the reactor would have to be dismantled unde ater in special pools using remote-control torches. Other procedu- es would have to be done in many shifts. To limit the radiation eceived by individual workers to acceptable levels.

Cost estimates for dismantling a 1000 megawatt nuclear plant

range from $50 million to over $1 billion (1982 dollars). The largest plant yet dismantled was the tiny 22-megawatt Elk River plant in Minnesota. The procedure required two years and $6 million, but provided few lessons for dismantling plants fifty times as large and hundreds of times more radioactive. Yet the low costs frequently cited by the nuclear industry are based on extrapolation of the Elk River experience. More revealing is the Shipping port plant, scheduled for decommissioning in the mid-eighties at a cost of $60 million to $70 million, according to a contract signed in late 1983. The difficulties that may be involved in decommissioning are illustrated by the cleanup of the disabled Three Mile Island plant, which has encountered a wide range of unanticipated problems and will cost well over $1 billion.

The 50 per cent estimate appears fairly reasonable Decommissioning, like waste disposal, also involves a non monetary cost — man-rems.This is dictated by the harsh logic of the fuel cycle. any attempt to relocate radioactivity has an exposure bill and a death roll attached to it.The fuel cycle is forever. And so are its/costs. Once it is started, any escape from the fuel cycle, like any attempt to close it, must take its toll of human resources The nuclear fuel cycle is forever.

VIII. From Luxuriant Power To Power ASA Luxury

THE economics of Nuclear Electricity from our brief survey of the nuclear fuel cycle, the conclusion is inescapable that atomic power is patently unsafe. As each stage, its fuel cycle throws up serious problems which, if they are at all amenable to solution, can only be tackled at the expense of occupational workers and of society at large. The risks nuclear power poses are so numerous, so grave and and so permanent or ineradicable as to be unacceptably high, whatever the magnitude of benefit from it.

Is nuclear electricity cheap? Even if it were much cheaper than power generated from other sources such as coal or oil in water, its human and environmental costs would remain too heavy for society to accept it rationally as an alternative to the latter. Indeed, even if nuclear power was free, it would still be seriously undesirable — at least at its present level of technological development or maturity and its high and rising social costs. But, as it happens, nuclear power is <u>not</u> cheap. It is much more expensive in relation to hydroelectricity and power generated coal or even oil-fuelled stations. Commercially nuclear fission represents the most expensive form of producing power known to society.

The nuclear industry all over the world of course denies this — ironically just when it is in the grip of the worst-ever economic crisis known in any sector of energy generation. The

industry can no longer survive without enormous subsidies. In the United States, which has the largest contingent of power reactors in the world it is a state of financial collapse with big companies going bankrupt. The global commitment to building atomic power stations has declined by a huge 31,000 MW over the past five years.

In place of the decade-old-projection of one million or more megawatts of power generating capacity to be installed by 1990, no more than 300,000 to 400,000 MW are now expected to be commissioned. Each year, country after country is cannelling plant orders In the U.S. alone some 87 plants have been cancelled. (Note)

Nuclear power is on therun because it is too expensive - In most parts of the world its viability has evaporated. Its capital costs have increased twice as fast as those for coal-burning stations over the past decade -- despite all the anti-pollution modifications ordered in these. Today they are 50 to 120 per cent higher than the latter, kilowatt for kilowatt in most countries in the West. Unit costs of nuclear power generation are roughly 50 per cent (in some cases even 90 per cent) higher than the energy costs of wet coal-fired plants.According to an estimate, if all the power used by Americans were to cost as much as the electricity generated by nuclear plants scheduled to go into operation in the mid-eighties, the country's electricity bill would rise by 130 per cent. (Note)

Today the average cost of nuclear electricity can hardly in the West is so high it can hardly compete with even

crude oil. For new nuclear plants to be competitive, oil would have to priced at between $60 and $100 a barrel, as against the current price of about $30 a barrel. As a source of heat, nuclear electricity compares with oil priced at $240 a barrel. It is plain that nuclear power has look out on all the advantages presented to it by the decade-old energy crisis and the shooting pricesof competing fuels.

No one in their senses expects its poor cost-effectiveness to improve in the foreseeable future. The OECD's atomic energy agency, a part of the world nuclear lobby, has had to concede that "there is not ₰ remain commercially viable in a climate of uncertain and variable markets". Going by the more informed and reasonable of estimates, nuclear capital costs will increase even more rapidly in the eighties than in the past, over coal capital costs and make atomic power even more (20 to 50 per cent) expensive that coal-fined electricity. "The day when nuclear power will be the world's leading electricity source now seems to have been postponed indefinitely." This is the pitiable present state and projection of unbleak future of an industry which, it was predicted, would generate power "too cheap to meter". Today, nuclear power has become too expensive to hook up to a meter. (Note)

The historic prediction, made about three decades ago/in the U.S. well before a commercial power reactor had been set up, is entirely characteristic of the nuclear lobby's logic of anticipation. It declares all problems solved, in advance, all possibilities fulfilled, prior to the event.

In India too a similar if somewhat more modest prediction was made about the same time by Homi Bhabha. In drawing up India's atomic power plan, he declared that nuclear power would be competitive with electricity generated from coal-based stations remote from coal pitheads. Leave alone a serious analysis of costs not a single rigorous calculation was or has since been cited by the country's visionary nuclear planners in support of this claim. Nevertheless India was launched on the nuclear path with the AEC exuding confidence that it would set up 2,700 MW of power generating capacity by 1980. Clearly the visionary planners' vision had proved more important than realistic planning. In keeping with the vision, a number of claims have been made about nuclear power and its cheapness, not merely potential but actual. Thus the DAE sending claimed, over five years ago, thatTarapur power only cost 9.6 paise per kwh when its real cost was close to 15 paise.(Note) More recently, Kalpakkam (MAPS-I) power, it was announced, would only cost about 30 to 35 paise per unit, when its actual cost even at capacity factor levels that have remained something of a dream for the DAE in CANDU reactors, is likely to be 90 paise or more per unit.(Note)

But even more recently, the DAE made the extraordinary claim that TAPS has been selling its power at 10 to 12 paise a unit.(Note) According to a DAE document, TAPS is receiving about 21 paise per unit of power sold and its officially akcnowledged 19 paise per unit.(Note)

That such extravagant claims which are totally negated by the DAE's own published documents, can made at all must be treated

something curious or even bizarre.

The DAE's original statement of economic reability of nuclear power itself is more a curiosity. The basis of comparison between nuclear and coal costs has been attend a number of times, in an inexplicable manner. Originally, nuclear plants were declared to be competitive with coal-fired stations situated at a distance of 500 ~~mm~~ miles (800 km) from the nearest coal pitheads. Later by the mid-seventies that figure was ~~xmm~~ modified to 600 km, and the comparable size of the nuclear station was for the first time stated as 2x200 MW. Nuclear power was reiterated to be "more economised" in the long run", if acccunt is taken of the costs of transportation network, compactness of nuclear fuel and the learning specimen in nuclear power as well as its imminent upscaling to 500 MW size units.

By 1980-81, the criterion was further modified. "At current prices, a nuclear power station of about 2x235 MW capacity located beyond 1000 km. of the pithead... and operating at 75% capacity factor is economically competitive with a thermal power station of comparable capacity and operating at 60% capacity factor".

By 1983-84, however the entire litany was dropped from the performance budget. But recently Raja Ramana, who took over as AEC chairman, has claimed that nuclear stations (2x235 MW, capacity factor 75%), can beat coal-fired thermal stations of ("currently chosen") contemporary size (210MW) capacity factor 60%) even 800 km. away ~~fxx~~ from the pithead.

The very basis of these claims is fragile. To start with, it involves comparing nuclear power with coal-thermal power but excludes hydroelectricity. Secondly, it compares nuclear unit with coal-fired stations 600,800 or 1000 km. away from walbelts, when it is known that such transmitting power is considerably cheaper than transporting coal, it is best to built the latter at coal pitheads. Particularly objectionable is the assumption that nuclear plants will have a ~~xpx~~ capacity factor of 75 per cent, when historically it has been under 55 per cent in this country and only about 25 per cent in the RAPS, the only fall-fledged CANDU station on which theentire DAE programme is based.(As far the claim that the long rum nuclear power will be even cheaper thanks to the upscaling of plants to 500 MW, etc. it is a pious hope. The design for the 500 MW reactor exists only on paper in the DAE; it is still to reach the drawing board.

However, even on all these assumptions, nuclear power is demonstrably and decisively dearer than coal-based electricity. Nuclear capital costs are roughly Rs.23,000 per kw of installed capacity (Rs.17,000 per kw for plant andmachinery, plus another Rs.6000 per kw for the initial charge of heavy water). Coal capital costs are roughly about Rs.7000 per kw. These figures are for plants that will go on stream in 1987 or 1988, they are in constant 1983 rupees. ~~Capx~~ Capital costs account for about two thirds of unit generating vosts in the case of nuclear stations, but for only a third to two-fifths in the case of coal stations.

Thus a Rs.23,000 kw nuclear plant will generate power at

bout Rs.1.30 to Rs.2.80 per kwl, depending upon whether the apacity is about 70 per cent or about 35-40 per cent. The corresponding figure for a coal-fined plant are 60 paise to Rs.1.10 aise per unit, give or take 10 to 20 paise in each case.

In the most probable case, based on past experience, the apacity factor for the nuclear station will lie closer to the essimistic (35 to 40%) level. Its costs are therefore likely to e about Rs. 2 per kwh, whereas in the case of the coal-fired pla t, likely unit costs are about 70 to 80 paise per unit. In case e are considering the more relevant, contemporary thermal size of 500 MW for which indigenous technology exists, the costs ould be lower by about 10 paise per unit.

The most probable unit costs of nuclear power are thus two-to two-and-half times those of coal-based power.

These calculations are based on extremely ~~xxxxxx~~ conservative assumptions. For instance, they assume that the operation and maintenance costs of nuclear stations are <u>lower</u> than those of coal-burning plants, and that the manpower ratio is the same in both. This is far from true. In reality, the O & M costs of nuclear plants are 15 to 20 per cent of total generating costs. (only three per cent in the case of coal-thermal units). The man-power-megawatt ratio for the nukes various from three to five while in thermal stations it is about 1.5 to 2.30. Hence the operating costs of the nukes are much higher. Another reason for this is their high cost inventories and the instant need to replace worn out or malfunctioning components. The annual spares bill

can be as high as five or seven per cent of the cost of sales. Another assumption is that atomic fuel costs only about Rs.1700 per kg. and has a burn-up of about 7 MW days per kg. In reality, the price would be higher. Also the costs of the nukes are much higher that are revealed by capital costs, since a nuclear plant takes twice as long to build as a coalfired station.

It all this is taken into account and the right corrections are made, the cost of ineffectiveness of nuclear power increases. Nuclear energy is three or four times dearer than electricity from coal.

These are only the <u>direct</u> immediate costs of nuclear power. If the indirect team costs of the fuel cycle, such as those of water disposal, decommining or reprocessing (in the recycle case) are added, the picture looks even more skewed. Waste disposal alone would contribute some Rs.6500 per kg. to the cost of fuel (Note) and thus raise it five times over (adding another 17 or 18 paise to the unit generating cost). Decomminging delivers another blow, equivalent to 25 to 59 per cent of the capital costs of nuclear plants, and hence another 30 to 50 paise to their unit generating costs. Add reprocessing (about 25 to125 per cent to unit costs) and that is another increase of 50 paise to a two rupees. The total now comes toRs.4 to Rs.5 per unit! This is about <u>ten times</u> the cost of electricity generated in India's existing coal stations. It is also five to seven times higher than power from a coal-based plant that would be ready about the same time (1987-88) on an the dearer nuke.

Shocking as this is, it is not all. If the hidden costs in terms of R & D expenditure incurred so far to develop the nuclear power programme -- assuming that as much as half of that can be imputed to causes, including military ones, other than research relevant to all the steps in nuclear power generation -- and the infrastructure, training and manpower costs of the various establishment under the DAE, are added to these already large numbers, they would-well by another 20 to 30 per cent.

If all the power generated in India were to be priced at this cost power level, the country's electricity bill would increase ten fold. or fourteen fold.

Even more ominous, the DAE does achieve the target of installing 10,000 MW of nuclear capacity by 2000 AD it would double the power industry's generating costs, although it will only contribute ten per cent to the total power output.

Nuclear power is not only unsafe and environmentally dangerous, it is economically disastrous. It is much more expensive than coal-based power not only in the West, but also and even more so in India. To rephase Bhabha, no power is as expensive as n-power; any other power is preferable to atomic energy.

IX - The Politics Of Nuclear Power

The Hidden Logic Of Dependence

The foregoing makes it plan that nuclear power is neither reliable, nor safe nor even cheep. It is the dirtiest, environmentally most hazardous and economically not expansive form of electricity generation that has ever been commercialised. The claims that the nuclear industry, and the DAE in particular makes in respect of the safety and economic competitiveness of atomic energy are not merely untenable. They show the industry to be guilty of the most pernicious form of deception on nuclear risks and costs, both economic and environmental.

The shoddy calculations of Ramanna, discussed earlier, are an insult to ordinary human intelligence. And yet, they are made, reiterated and publicised ad nauseam as the gospel truth. Dubious ludicrous assumption constitute the sole basis on which the India scientocracy declare with Olympian confieence and monumental arrogance, nuclear power is "inevitable", that it is the only source... on which we will have to fully depend in the future," or, to digress to a Pakistani variation on the same theme, that it is "simply a matter of survival".

The less fanatical of India's nuclear proponents concede usually privately, that atomic energy is costlier than coal-electrical power but argue that its higher cost is no more than the price the country has had to pay for "self-reliance", for

nergy "independence", fro having to struggle on its own to
op "the energy source of the future". Thus, delays,
ct schedules and high cost overruns are explained as being
walkout
o the conditions/from collaboration with the DAE in 1974
wing the Pokhran blast and a ganging up by the London club
world of nuclear suppliers and exporters) against
a. Meanwhile the DAE has soldiered on, hold the proponents of
view, and is bound to be able to develop the necessary cost-
ctiveness sooner or later, when a genuinely indigenous base
the manufacture of nuclear-grade equipment is built by the
try's own efforts. The struggle for self-reliance thus justi-
the high cost of nuclear power.

Nothing could be a more grotesque travesty of the truth.
ing can conceivably justify a form ofpower that is ten times
tlier than it promised to be. Admittedly the Canadian walkout
years ago was a setback for the Indian nuclear programme. But
t was so because, in the first place, the DAE was helplessly
pendent on Canada's AECL for the design, construction and com-
sioning of the CANDU type reactors. This dependence was built
o the vary basic strategy of the nuclear programme of which
CANDU reactor has been the cornerstone. What is worse, this
pendence on the Canadian natural , heavy water reac-
r-model continues to this day, fully ten years after Pokran.
each one of
/its essential aspects, the DAE'sdesign for the RAPS, MAPS, Naro-
and Kakrapar stations -- or all of the ten reactors to which
is committed -- is an exact replica of the Canadian Douglas

int plant, incidentally, the worst performing of Canada's and world's natural uranium fuelled power stations besides RAPS, course. In Canada, this design was significantly altered in the xt generation of layer pickering 4 x 516 MW and Bruce (4x750 MW) actors. In fact the pickering project was launched, with the modi-ed design, in 1962, a year before the completion of constuction Douglas Point and about the same time as RAPS-I's erection began.

In India not one serious basic-level modification has been fected in the Douglas Point design. From the fuel geometry, ough the reactor configuration and physics and the coolant system rameters to the dimensions of the crucial components and most of e control system design everything essential remains unchanged. e only changes made in MAPS relate to the "conventional" side and e electrical systems, not the reactor.This is basically true of rora as well, where for instance, some inor modifications of the undations (civil engineering works) and containment system have en made. The only post- RAPS change has been the "up-rating" of e racter power level by simply increasing the flow primary heat ansport system (PHT) flow. and a slightly different material rconium-Niobium for presure tubes (at Narora).

For the rest, whether it is pressure tube diameters or mber of channels per reactor, or inlet and outlet temperatures of e coolant the reactor design is identical.The PHT flow increase s about the simplest, though not a reliable,way in which to tain a 10 per cent rise in net power from 2#3 MW to 220 MW — nd thus to claim that the "new reactor design" has a rating of 35 MW (gross).

s stagnation continues 20 years after RAPP was launched in
and the Pickering series commenced in Canada. The DAE has
even begun to draw up a detailed design for the 500 MW
(which may have a scale-economy of about 10 to 15 per cent)
spute as to whether it is BARC's or PPED job is yet to be
ed. It will take years even when the wrangle is ended before
sign can be properly evaluated and finalised.

eanwhile, the DAE is reering round to the idea of <u>importing</u>
reactors and power stations in the 400 to 500MW range.
a justifies this on the absurd ground that importing a nucl-
actor is no different from importing a coal fired thermal
on. Of course, it is. Coal-electrical stations do not produ-
tonium. Nor do they consume fissile material that can be
o make weapons. If not imports of reactors using enriched
m (which India does not have the capacity to produce) can be
ithout accepting onerous safeguards and paying a heavy poli-
price, none of natural uranium — heavy water systems are
le without a huge safeguards tag attached to drums containing
tter either.

The Indian governments experience with the US in TArapur's
and with the USSR over the heavy water imports of the seven-
is clear proof of this impossibility. Despite its friendly
ions with India, the Soviet Union refused to dilute the
tuity and pursuit clauses on the heavy water deal. And the
ur tangle is too well-known to need another mention.
eactor imports will constitute nothing if not a ignonimious

treat from and renegation on the goal of self reliance which, onically, the DAE has itself tem-tomed for long. Any resort to actor imports, even as a temporary measures as in Tarapur's se will tend to compromise this country further in relation to he dominant nuclear suppliers and intensify its dependence on em. Its political implications are grave.

But the very mention of reactor or station imports after ousands of crores of rupees have been sunk into subsidising e DAE, is an implicit recognition of that department's failure d inaapacity to absorb, master, implement and develop nnder chnology. An import deal would at once constitute the most athing political indictment of the DAE.

And yet, there is reason to believe that the recognition of e DAE's failure will remain entirely silent — just as did its ny infirmities which compelled it to retreat time and again om theenergy independence objective.

The entire atomic programme of the country has always assumed pendence — excepts in strategic matters. Some kind of 'coopera- on' or foreign collaboration and aid has remained axiomatic or the DAE. Apsara, India's first research reactor 1956 sed enriched uranium supplied (also fabricated) by the U.K. imilarly, CIRUS, (40 MW (thermal), centered 1960) from which lutonium used at Pkhran was extracted, was designed by AECL, anada, and used heavy water supplied by the Americans, from whom t derived the last two letters of the acronym.

Again, the Baroda, Tuticorin and Taleber heavy water plants

re designed or erected by W.European consortia/firms. The very ct that the DAE had not started planning for heavy water produc- on some five years after the Rajasthan power project was launched ints to the strength of the dependence axiom.

It must be conceded right away that the various collaborations ve not involved nor always led to completely skewed forms of pendence, in which India would be the loser. Just the contrary s true of the early period of collaboration, during which the DAE ade some gains in acquiring familiarity with atomic energy with- ut paying a heavy or even corresponding price for them. But after okhran the balance shifted decisively and aggressively against he DAE and this shift meant that it would not be able to build n its past gains. Secondly, these gains never amounted to a astering of the technology or furnishing of the basis for doing o in the proximate future. The nature of the collaboration rrangement that the DAE opted for, the particular, limited tech- ology choices it made within them, and its generally weak (es- pecially after 1974) bargaining power, all ensured that it would emain one of the world's big laggards in nuclear technology in spite of being one of the biggest spenders of resources on atomic power.

This lag is revealed in a particularly amplified form in India's heavy water projects, for long organised as the Achilles heel of the nuclear power programme.

Each one of the projects, (barring the tiny one at Wangal based on the power hungry electrolytic process) has been a disas-

(Note)

classic study in technology bungling and mismanagement.

their inception, (Baroda 1977, Tuticorin 1978, Tauher? and
1983), they have together worked at an aggregate capacity of
than ten per cent! Nothing suggests that any of them has fully
lised or is likely to do so in the immediate future.
ne technology they employ is either too sensitive to the
ty or purity of the impact or too hastily industrialised with-
dequate testing and scaling up and too hazardous for it to
satisfactorily. The HWPs have had a long and disturbing
ry of accidents, breakdowns and near-collapsing.
)

The DAE has all but despaired of rectification of the
ous faults of the plants or of linking than to the unreliable
and power supply from its station. It has now opted for heavy
plants (based the Kota design) with their own capture power
s.The first one of these to be located at Manuguru in Andhra,
nost a frightful Rs.422 crores with a foreign exchange comp-
of Rs.50 crores.

Even if it die work at some respectable level of capacity use,
ill produce heavy water at a cost upwards of Rs.15,000 a kg.
3 rupees). This is about five times the national price that
DAE assures in charging power projects a so-called lease rate
heavy water.

It is significant that the foreign exchange component for
e new HWPs should continue to be high, as great as 34 per cent
the Thal-Vashet plant now under construction. This

shows that the DAE cannot break the vicious circle of
nce. Indeed it should not be expected to do so. Its premis-
and sustained by
too deeply rooted in/the logic of dependence for it to be
do so. Dependence is only one component of the political
f nuclear power. The other is related to the unconscious-
h specific weight of the DAE in the entire energy and
ment planning apparatus of the country. Its status, as the
ivileged department of the government of India, and also
ost closed secretive and bureaucratised part of the scienti-
d technology establishment, has put at way above public
ny. With their unquestioned access to vast sums of money
her resources, their exalted position in the hierarchy
close
ia's scientific brahmins and administrators and their/
with the military establishment, the DAE's top officials
cumulated vast powers to decide what energy choices this
y ought to make and at what and whose cost. The DAE does not
er itself accountably to the public and by and large even
rliament, leave alone its employees. This concentration of
rity in the hands of men who are known for their abiding
mpt for public opinion, indeed for the people, has grave
cations for any notion of a democratic polity. Logically, it
ls the triumph of closed, irrational, minority decision
g on issues that concern the fate of millions of people,
energy options, their safety, and the cost that their future
rations must pay for these choices. It simultaneously spells
rout of openness in decision making and greater popular

entation within it. It can only strengthen political

sm.

This is a reactionary consequence, for any idea of democracy

is not journalist. It can only open up yet another

ioning prospect, that of the despotism of the scientific

in, the absolutions of the "experts" the unchallenged rule of

nowledge of the atom.

A Requiem For The Nuclear Dream

The Bleak Future Of Atomic Energy

This returns us to Bhabha's grand nuclear energy plan, most comprehensive, ambitious and expensive effort ever nched with the objective of effecting a transoformation of ian Society by means of technology.

The plan was conceived in the early years of Independence three steps, logically leading from the one to the other: rst, build "duel-purpose" natural uranium fuelled reactors generate power as well as produce plutonium from reprocessed ent el. Second; feed the plutonium into fast breeder reactors produce more power, more plutonium and, at the same time irradiate thorium to produce U-233. And third , construct 233/thorium beeder reactors to generate vast, potentially limited quantities of electricity for hundreds of years.

This route to nuclear abundance -- 2 lakh MW and all the suring prosperity -- would obviate the need to set up an pensive uranium enrichment facility, and, more important, uld maximise the use of thorium, of which India has very rge reserves. It was a prior the most logical the easiest thway to progress and prosperity.

Underlying this plan adopted by the Atomic Energy Commis- ion was a whole series of premises -- till then untested but evertheless accepted: That nucleonics is the quintessential, he ultimate, technology of the future; that the principal

the field of energy for a poor developing country like
as in the developed world generate more and more electri-
part of a project of "electrification of society", that
power is the cheapest means of doing so; and that its
as a technology is directly predicated upon the knowledge
d by the new science of the atom and hence that there are
rmediate steps (such as design, engineering, safety evalua-
caling-up, etc.) with their own autonomy, their own specific
s of problems, possibilities and limitations, which must be
hrough before the technology becomes commercially viable
erefore a candidate for a large public resources commitment.
is last view, the proving of the technology is a matter of
detail, a repetitive job; for, in principle i.e. at the
act level of nuclear science, the basic problem has already
solved as will be any other that might arise.
At least in retrospect, all these assumptions appear wholly erroneous.
an now see that nucleonics is just one of many post-war techno-
es. It is no longer considered advanced and is not half as
rtant in its content or potential/actual impact as, say,
tronics, informatics or photoroltaics. It is also not difficul-
to appreciate that electricity is only one and a somewhat expen-
e if versatile, form of commercial energy, which in a poor
ntry can only represent a small, albeit growing, fraction of
tal energy consumption. It is not difficult to question the very
ncept of 'electrification of society', especially one based
clusively on centralised power generation, as being unappropria-

social needs and wasteful of social resources. It is plain, hat in an underdeveloped country such as India, electricity ntly represents and for a fairly long time likely so represent a fraction (01/3 or 80) of total commercial energy consumption in turn is only about half of the total domestic energy in- Nuclear power, which can only provide the base-load (as net for peak load) for the electrical system (itself about a of total energy consumption), is necessarily limited under conditions to a minor fraction of the energy sector. The load itself amounts for less than half of the peak load in parts of the country. Thus the AEC's original assumptions can been seen to exaggerated the role of atomic energy in a parti- rly gross manner.

It is also to be found at the root of many other grandiose nicist schemes for social transformation. In sum, this con- tion and the fatal flaws in the numerous assumptions underlying stand nuclear plan, reveal the utter insensitivity of the AEC's nners to society and to its needs as well the fundamentally ealistic (because <u>a prioristic</u>) nature of their schemata. e technology's distance and autonomy from science is refused, plan based on it must be filled with assertion, hope, theology

The nuclear dream, the AEC's entire plan, was itself variously d greatly flawed. It is possible to trace some of its faults d its extravangance to the initial flush of enthusiasm that isted in the heady days of atomic energy. It might thus be pos- ible to condone some of these faults. It is however impossible

t the reassertion today of the original faith, with any
y -- not after two decades of experience of nuclear power,
ly not with our present knowledge of its horrendous safety,
, of its ineliminable hazards and its doomed economies. It i
late in the day for that. It is equally impossible not to
he sheer cynicism and duplicity — as distinct from the
e and optimism of their predecessors — of those who make
ssertion.

ut does nuclear power have a future? It seems extremely
ely. As we know it, and as it is developing today, atomic
based on thermal (moderated) neutrons poses innumerable
problems as well as an unacceptable economics. Most of
problems originate in the nature of the technology itself.
tom concentrates within itself vast quantities of energy
fission releases in the case of the nuclear reactor, which
rts just about a third of it into electricity, via steam.
uclear reactor is necessarily far more expensive in relation
al-electrical plants. It is, must be, far more elaborate and
ex, because it has to deal with huge and often unpredictable
s of energy; it needs more capital goods inputs, costlier
rials methods and devices, more expensive instrumentation
controls to cope with high energy in and corrosion which
ot be contained in ordinary, standard (and less expensive)
pressure, high temperature equipment. Nuclear grade componen-
re costlier. Their cost of replacement or of maintenance,
uch higher. The more elaborate the steam production system, th

unsafe the more precarious the numerous equilibria it must maintain, the dearer it will be. Any compromise on expenses necessarily makes the system unsafe.

Secondly, because an incident in a nuclear plant is more likely and much more powerful in its impact, the plant must have more elaborate systems for warning, alarm shutoff, dousing, core cooling, emergency control and (physical) containment (the dome) etc. This necessarily entails considerbly higher costs, which cannot be offset by the low (often politically rigged) price of uranium fuel, since this forms a very component of total generating expenses. But here another contradictory phenomenon comes into play. The greater the "paraphernalia" of safety devices, the more elaborate or complex the safety system gets, the lower its reliability. In general, reliability decreases beyond a certain point with system complexity and a compromise (trade off) is reached in practice, which usually leaves many safety problems untouched or only partly resolved. Thus, in practice, the reactor becomes much costlier but only marginally less unsafe.

The other clutch of intractable problems focusses primarily on safety: radioactivity releases and exposure to toxins at each stage of the fuel cycle. The worst of these relates to high-level "wastes" in spent fuel. Not only is there no solution in sight for these; but there may not be one at all. No known material devised by human effort can keept its integrity for thousands or millions of years, till the wastes stop seething with radioactivity. No known geological formation can store than safely.

In tapping the atom, nuclear technology jumped the gun, quite literally. Its proponents presumed that all the problems associated with it would be solved for there can be no insoluble problems. The success of the technology was proved though and in destruction. It was created to destroy. Himanty's actual experience with atomic fission does not suggest that it is viable as a source of commercial energy.

Clearly, if neither the basic limitations of the technology nor its past performance justify the thesis of inevitability necessarily for desirability of nuclear ~~per~~ power, what, except an abundance of Pure Faith and unfounded hope, can do so? The faith has many dimensions and components. An important one ~~is~~ underlies the assertion that the problems the nuclear power bristles with can and will somehow be solved one day. With experience and once the hump in the "learning process" is crossed, capital and generating costs will fall. In reality, just the opposite is true. In the U.S. which has had the largest experience with atomic energy, the "learning effect" is remarkably weak (Rumaneff, p.20-21). Inflation adjusted nuclear costs have tended all over the world to rise, not fuel, with time — and due not only to increasingly strigent safety regulations that add millions of rupees to fixed investment each year. Even if coal prices were suddenly to double or , power generated from burning it would still be cheaper than atomic electricity in most countries of the world, certainly and with a vengeance in India. Even if in addition, stringent regulations to eliminate 90 or 95 per cent of the harmful emissions

l fired stations were suddenly to be imposed, coal's edge
ill remain.

rmal-nuclear power is, to put it mildly very unlikely to
omically viable in the foreseable future. And for all time
that we can imagine it is certain to remain grossly unsafe,
re so than any other known energy source.

es the fast (breeder) reactor represent an alternative to
ght/heavy water reactor? Nuclear proponents, and particularly
st its dogmatic fringe amongst them, have argued that the
eactor, based on a better ~~mmx~~ neutron economy does. (This is
a minority view, for fast breeders account for no more than
r cent of all nuclear reactors inoperation or ~~pxxxxx~~
ed). However, the first reactor's neutron economy is far less
esting (since after all, 90 per cent of all reactors are
ed" and only a third of those that are not produce electrici-
han its safety. It is a barely, and rather clumsily, controlled
or more accurately several hundred "critical masses" or
pendent potential bombs put together in the core. The ~~xxxx~~ fast
der reactor only concentrates -- by orders of magnitude — all
problems and hazards of the thermal nuclear reactor. The capital
s of the "experimental" fast reactors which follow few safety
lations, are at least twice as high as those of the thermal
ctors. (Note)

In India's case the fast breeder test reactor (FBTR) at Kalpa-
m, magnifies all these problems by several multiples. Its fuel
not only problematic, it is unproven and potentially more

ous than any used elsewhere elsewhere. The reactor is, to
curdely, amateurishly designed and may yet be started with-
mentary
afety evaluation and operational norms even being attempted.
ikelihood of any safety procedures being established is all
ower because the DAE is in a hurry to get the reactor going,
ok or by crook. All in all, the FBTR is the greatest poten-
hazard so far imposed by the nuclear power programe. It is no
eration to say that the fast reactor represents a threat as
as the atom bomb itself. It could explode precisely like one,
consequences that are too horrifying to contemplate.(Note)
But for the DAE, the fast reactor represents a hope, even a
nd. If the CANDU type thermal reactors have not proved
essful (thanks to "certain unforeseen difficulties", technical
s, supply delays and the Canadians walking out etc.) the fast
tor ~~just first~~ first might work and rescue the country's
ntegrating nuclear power programme. The fast reactor is the
second line to defence. (But now it isplanning a third one
as it were, in anticipat ion. That is nuclear fusion is first
ase fission with thermalised and fast neutrons does not work.)
would turn out to be itse only hope even if the desperate last
, and the only face-saving device that is accessible to it —
ides another bomb.

The entire logic and the politics of the fast reactor progra
, as of the entire nuclear power plan, reeks horrifbly. The
refaction has reached too far, too deep. For the DAE, Nuclear
er has become, as the chairman of the Pakistani atomic energy

ission put it, "simply a matter of survival". It could
me exactly that, and very soon, for many people in India.